ENGINEERING

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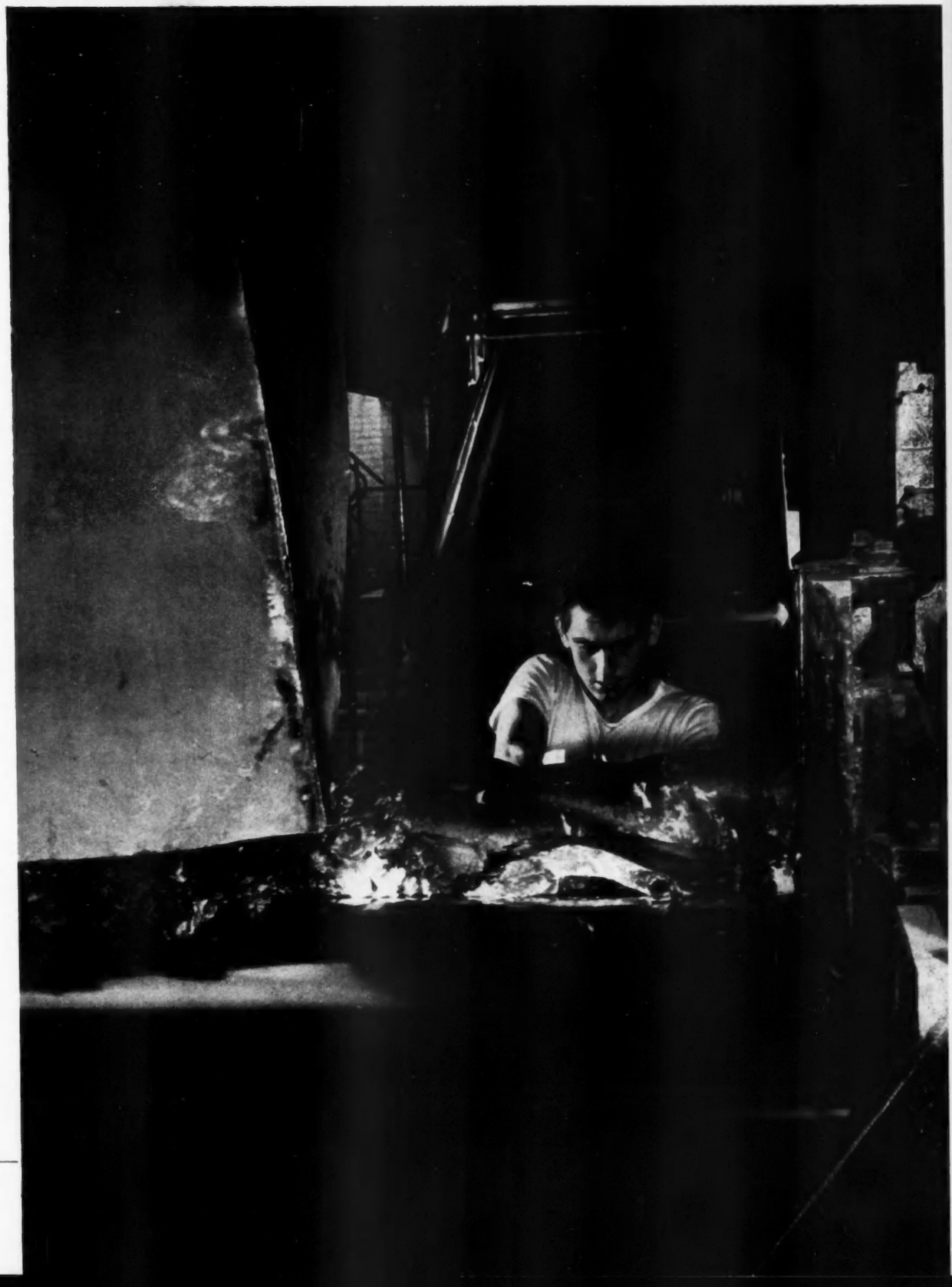

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BO-ALTERNATORS
CH 275MW

SISTENT RESULTS
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TRESSED BRIDGE
THE RIVER TRENT:
S 275 FT.

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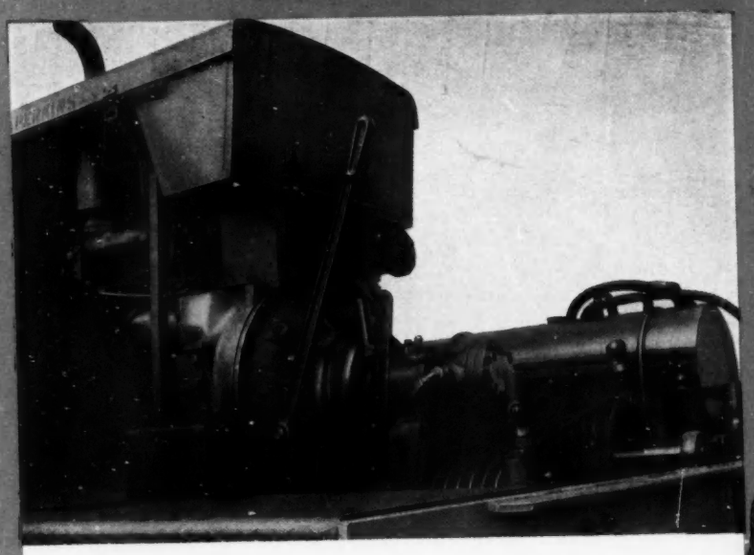
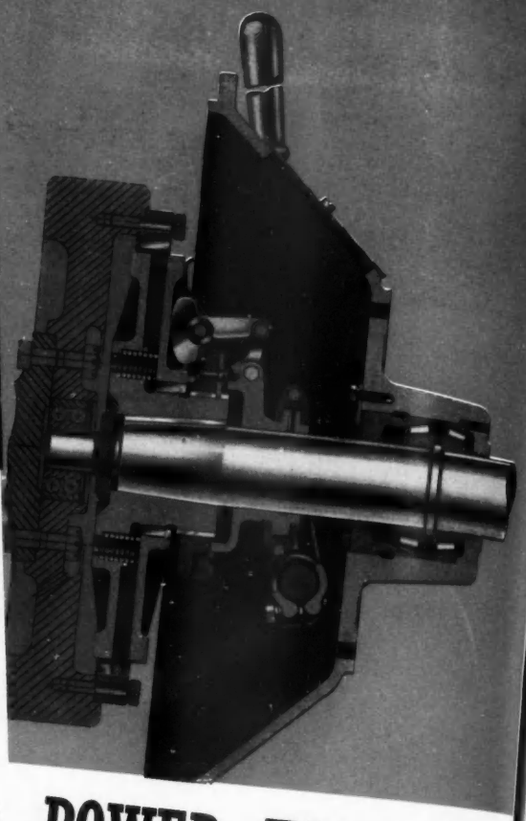
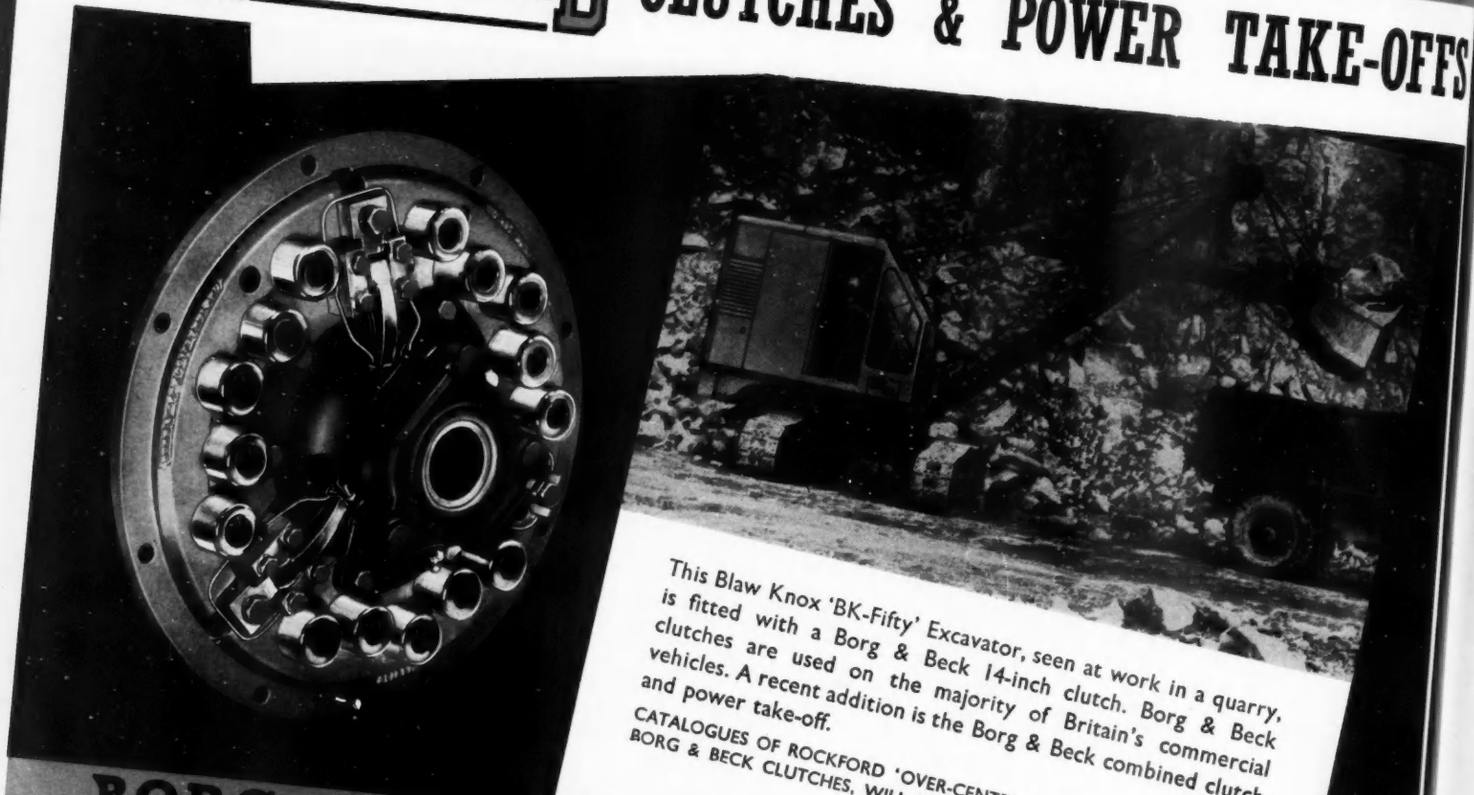


This illustration shows a Rockford 11½ in. power take-off and 'over-centre' clutch unit on a Perkins 4-cylinder diesel engine on the Blaw Knox PF-90 Bituminous Paver Finisher. This interesting machine can lay pavement in any width from 8 ft. to 13 ft.
At right, a typical Rockford power-take-off unit.



ROCKFORD CLUTCHES & POWER TAKE-OFFS



This Blaw Knox 'BK-Fifty' Excavator, seen at work in a quarry, is fitted with a Borg & Beck 14-inch clutch. Borg & Beck clutches are used on the majority of Britain's commercial vehicles. A recent addition is the Borg & Beck combined clutch and power take-off.

CATALOGUES OF ROCKFORD 'OVER-CENTRE' CLUTCHES, AND BORG & BECK CLUTCHES, WILL BE SENT ON REQUEST.

BORG & BECK FRICTION CLUTCHES

BORG & BECK COMPANY LTD., LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

ENGINEERING

PUBLISHED EVERY FRIDAY

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Spring of Discontent

It has not been an easy winter for the engineering industries. The adjusted index of industrial production put out by the Board of Trade showed a small increase in activity for January (the latest available month) compared with the same month in 1957, but figures of this kind can be misleading. Buoyancy in engineering over the last few months has owed a great deal to the record business done by the motor-car industry, and shipbuilders are still clamouring for steel plate. There are other sections, however, where overtime has disappeared and in some parts of the country there is short-time working and growing unemployment.

There are other straws in the March winds which suggest that some sections of the industry may have a bleak spring and summer. There is no sign of an improvement yet in the state of business in the United States. Export markets are becoming increasingly difficult as countries producing primary products feel the impact of the severe drop in world commodity prices in the second half of last year. World trade has indeed ceased to expand and this country's share of it continues to decline slightly. There is a record shipping tonnage laid up owing to depressed freight rates. The order book of the machine tool industry and plans approved for the building industry (both significant indicators of the outlook for the engineering industry as a whole) have been declining for some months.

The industry is poised at the moment in an exceedingly delicate position. If the boom in the motor-car industry were to come to an end in the next month or two, though fortunately there are no indications as yet that this is going to happen, its repercussions on the rest of the engineering and metals industries might be profound. Previous recessions among motor-car manufacturers have had a limited effect on their wide range of suppliers owing to full order books and over-full employment. This time the effects might be different and the steel industry in the Midlands would also now quickly feel the impact of reduced orders. It would not take a great deal for the whole of the engineering industry to be put into recession.

It is only a month now until the Budget; within the next few weeks the final touches must be put to Government economic strategy for the rest of the year. The Chancellor of the Exchequer is in a very difficult position. He has to guess the likely trend of activity in America and the outlook for United Kingdom exports before the seasonal swing in the United States can give any clear indication as to when the American recession is likely to come to an end. It will therefore not be easy for him to decide whether the world situation is going to be basically resilient during the summer months. There is likely to be a spate of advice, however, to keep up the credit squeeze, for many think that there will be pressure on sterling in the autumn as there was last year and that the prime object of Government policy should therefore be to maintain the value of the pound and build up a surplus on the balance of payments. Political pressure is likely to force the Chancellor to think in terms of reducing taxation for the lower income groups (especially as the higher income groups had some relief last year) and all this adds up to a continuation of high interest rates for industry and its adverse psychological effect on long-term investment plans. It does not appear likely at the moment that there is going to be more than a small downward adjustment in Bank rate for some time to come, since comparatively high interest rates in London attract foreign short-term funds and create a demand for sterling.

It will therefore be surprising if the Budget brings much consolation to the engineering industries. It seems probable that the determination of the Government to squeeze out every vestige of inflation in the economy and keep costs down (a policy which at least makes sense in terms of new wage demands), as well as growing competition in export markets from countries which are faced with the same problems as the United Kingdom, is going to make business in most sections of the engineering industries at least as difficult in the spring as it has been through the winter.

In other words, it would be unwise for these industries to expect much assistance through Government action this spring to alleviate present business conditions. Those concerns with long order books are likely to come off best for they have plenty of work on hand; they can rely on a moratorium to wage demands from the A.E.U. until May, and in most cases cheaper raw materials than last year. Those dependent directly or at one remove on the expansion programmes of the nationalised industries will begin to feel the modest effects of the slow-down in the rate of expansion enforced by the Government, and those dependent on business from the building industry may face a chill spring and summer. But for the light engineering industries the possibility of reduced taxation (and easier hire purchase?) may mean a hope for larger sales.

Cover Picture. *Sulphur is being added to a mix in the rubber-mixing plant shown and when the correct degree of dispersion has been attained, the compound is fed on to the automatic take-off conveyor, immediately behind the operator, for cooling and slabbing.* (*Photograph by Nurnberg.*)

* * *

Plain Words

Children bitten by mosquitoes tend to scratch the spots. The spots become inflamed so that the itching, and hence the desire to scratch, becomes more pronounced than ever. It is not surprising that parents in the summer months are often heard to warn their offspring: " Don't scratch, you'll only make it worse." Indeed, the admonition might be adopted as a maxim. Children are not alone in sometimes aggravating the causes of a distemper in their attempts to relieve the symptoms.

Many people seem to pursue their aims by methods likely to secure the very opposite effects. Examples are legion. They illustrate how widely the mechanism of feedback affects our lives. Now engineering has given us a word for it, many situations may be better understood and hence be tackled more effectively. In a series of articles in ENGINEERING, Mr. Z. M. T. Tarkowski has shown how the principle of feedback may serve to clarify certain patterns of human relationship. A fault of personality may arouse a hostile response from other people, which aggravates the problem, thus creating further hostility and so on with ever increasing rancour. The man concerned may even make the situation worse by his efforts to resolve it.

Attempts to tackle any problem may be frustrated by a failure to understand the situation fully. Governments seem particularly unfortunate in this respect. Measures are taken to remove some anomaly, which merely submerges to reappear elsewhere. The matter may be illustrated by reference to the problem of monopoly and restrictive practice, which have been considered undesirable since they undermine what is believed to be healthy competition. Wherever agreements are discovered that seem to militate against the public good, steps are taken to break up the party. However, once the party is over, the gentler guests, who only feel safe in company, fall easy prey to wolves. A small independent firm may only be able to secure its fair share of the market by an agreement; lacking this protection, the company is unlikely to remain independent long. Thus an attack on a trade association may lead to the smaller members being absorbed by the larger; the result is more monopoly, not less.

Perhaps the fault here is a failure to recognise objectives. Efficiency and quality are more fundamental aims than competition, which may not always produce the benefits supposed. Efforts to encourage or create it may sometimes be misguided. Some people spend so much energy competing, they haven't any left for work. To deal with a difficult situation it must first be understood. Don't scratch it, you'll only make it worse.

CAPRICORN

Weekly Survey

Americans in Scotland

One of the most interesting aspects of the post-war development of Scottish industry, described in a special feature in *The Times Review of Industry*, is the way in which it has attracted American money.

Since the Second World War investment in Scotland by American companies has been of the Order of £40 million. Most of the plants benefiting from this influx of dollars are in the Glasgow area. The movement to Scotland has been to a great extent a result of the work of various organisations, notably the Scottish Industrial Estates, the Scottish Council (Development and Industry) and the Chamber of Commerce. These bodies together with the Board of Trade have publicised the facilities that industrial Scotland has to offer. These are: available labour; adequate factory space; the opportunity to enter the Sterling market and the possibility of participating in freer trade with Europe; and finally steel and subcontracted components available.

The first American industries to come in after the war were the office-machine manufacturers, followed by the earth-moving and tractor industry. Another big group covers electrical appliances and electronic equipment. Lastly there is a mixed bag including rubber products, sewing machines, chemicals and pharmaceuticals, mining equipment, machinery of various kinds, tools, soft drinks, razor blades, clocks and instruments. Among the Americans now established in Scotland are Burroughs Adding Machine, Caterpillar Tractor, Cleveland Twist Drill, Euclid Road Machinery, I.B.M., Pal Blade, Remington Rand, and many others. In all, some 40 plants are in production or under construction. Many are competing favourably with their parent companies. The American manufacturing techniques and know-how that they have introduced are in some measure a return for the skill and energy which Scottish craftsmen gave to the infant American economy a century and a half and more ago.

Express Freight Trains

The opportunity was taken last week when the general manager of the London Midland Region of British Railways introduced a new express freight timetable to comment on the effect of the railway modernisation on the efficiency of handling freight on rail. Mr. David Blee described as " only a modest beginning " the fact that there are now 60 more express goods trains running than a year ago. This represents an increase of 12 per cent in the number of trains operating as expresses over the year out of a total number of goods trains run on the London-Midland network of 7,700. London-Midland runs almost one-third of the total freight train miles of the British railways system a year.

The impact of the modernisation programme on increased efficiency of handling freight traffic is being felt in such ways as the introduction of new methods, the growing use of vacuum fitted trains and the application of work study. One of the hold-ups was the transfer of road collections to railway wagons and Mr. Blee said that more containers were being built of different sizes and types to meet the problem. The fleet of containers has increased from 32,000 to 40,000 over the last two years. This veiled criticism of road transport may be fair enough but the efficient transfer of road traffic to railway wagons at railheads is of cardinal importance in raising the efficiency of the railways, for in the long run one of the most effective forms of competition which the railways can offer the roads and which can ensure that neither the railways nor the roads over-expand is to organise more efficiently the transfer of a multiplicity of small but remunerative freights for bulk transport by rail from key rail points. Plans have also been made for concentrating traffic at main freight terminals and a substantial sum is being spent on new cranes.

The exact points at which the railways and the roads should compete has still to be determined. For long enough the public has been used to thinking in terms of a modern road system making gradually obsolete an old-fashioned rail system. Somewhere in the future, however, lies the problem of how to avoid the over-expansion of the modernised railway system and a modernised trunk road system. The sooner both systems can compete on approximately equal terms and so begin to solve this problem without outside interference the better for themselves and the optimum distribution of the nation's transport resources.

Coal Priced by Size

When it was announced last November that no further imports of coal were to be authorised it became obvious that the National Coal Board would need to take steps to keep the demand for the various types of coal in balance. The output from British mines may be in total equal to demand, but stocks of the small coal used by power stations are rising while the output of large coal is still falling. The Board has now decided to alter its price structure, increasing the differential between small and large coal.

The price of about 11 million tons of the larger coals used by industry is to be increased from 98*s.* by between 5*s.* and £1 a ton. At the same time the price of 10 million tons of small coal is to be reduced by 3*s.* from the price of around 88*s.* a ton so that there is a distinct incentive to change. It is probable that some sections of industry could arrange to use small coal instead, and the large coal thus released would become available for the railways and domestic consumers. Last year nearly 3 million tons of large coal were imported (over 2 million tons from the United States) so a very real switch from large to small coal will be needed if the demands of those who must have small coal are to be met from United Kingdom mines. Steps to stimulate the export demand for small coal by considerable price reductions have also been made. About 70,000 tons were recently sold to West Germany at 65*s.* a ton, a reduction of nearly 40*s.* from the price which was being asked about six months ago.

The price changes announced last week affect only about 10 per cent. of the coal used in the United Kingdom. It could be argued that even if these were only the first of a number of price alterations to be introduced, a more effective reduction in the use of large coal might have been achieved by increasing the price to the biggest users, the railways and householders, both of whom use coal in a very inefficient manner. Such a step would however have a serious effect on transport costs and on the cost-of-living index.

Degree Days

The conception of Degree Days as a means of exercising control over heating installations and of forecasting fuel requirements is by no means a new one in this country. The London and Home Counties Coke Association started the first Degree Day Service in 1938; and the service has been continued by the Gas Council. According to the F.B.I. *Fuel Economy Review* for 1958, the system has been used in this country mainly

in connection with horticultural problems; its application to space heating has been developed largely by American heating engineers.

Broadly, it has been found that to maintain a given temperature in a particular building the heat requirements are proportional to the differences between the outside temperature and a base temperature which is somewhat below the internal temperature of the building. In the United Kingdom temperatures are normally maintained at about 65° F and it has been found that the appropriate base temperature is 60° F. The degree day is a means of expressing the difference of degrees for one day between the outside temperature and 60° F. Clearly what is required in order to calculate heating requirements is the number of degree days in a given period below 60° F, since no heating is required for the periods for which the temperature exceeds 60° F.

Knowing the cubic content of the heated building, and the figure for coke consumed for space heating per degree day per 10,000 cu. ft for a building of given construction, the seasonal fuel requirements can be estimated for new buildings from the actual consumption in an existing building.

In this country Tables of Normal Degree Days showing accumulated temperature below 60° F Base for the months September to May inclusive are available free of charge from the Gas Council, Coke Department, 1 Grosvenor-place, London, S.W.1. England and parts of Scotland are covered by 14 areas for which separate figures are available based on monthly averages of temperature over 30 years.

Design Without Blinkers

Considerable progress has been made since the war by firms specialising in product design and development undertaken for manufacturing concerns. A series of articles in *F.E.D.C. News*, the monthly publication of the Federation of Engineering Design Consultants, discusses the part they play " in the contemporary pattern of industrial development." The first of these, in the February issue, discusses the relationship between the design consultant and industry, particularly the increasing use now being made of their services.

First there is the independence of outlook, traditionally the trump card of all types of consultants. A firm tends to acquire a specialised background—say machine tools or mechanical handling—but are not subjected to the same influences, managerial and others, as the man working right on top of his job. The design consultant worth his salt is organised to keep informed of all developments the world over, and trained to avoid stereotyped thinking. In the United States engineering design has long been strongly influenced by consultants, and some firms—such as Arthur D. Little Incorporated—have grown to a very large size. No firm in Britain has achieved their status, but there is little doubt that the idea of putting design work " out " is catching on. Those who did so after the war because they had not the capacity in their own design offices have found out they got a new outlook and a different approach. By his independence, the consultant should be free from the limitations inescapable to all but the largest manufacturing firms, and can concentrate on a project without the interruptions of day-to-day matters any chief engineer has to attend to.

Prospects for a Shipping Cartel

At the beginning of February there was nearly half a million gross tons of British shipping laid up, over 30 per cent. more than at the same time in 1957. Almost half of these are made up of oil tankers. In addition, there was over ¼ million tons of foreign shipping laid up, nearly twice as much as in January last year. To some extent, the comparison is unfair because the shipping boom was in full swing a year ago owing to the Suez crisis. The general depressed outlook for world shipping, however, is only too clearly reflected in the annual report for 1957-58 of the Chamber of Shipping of the United Kingdom issued last month.

It is not surprising that under present conditions, when freight rates of tramps and oil tankers have both fallen catastrophically over the past year, that shipowners' minds should turn to some form of collective agreement to limit freights. In the section of the annual report dealing with deep-sea tramps, the Chamber says: " Should there be a strong desire among the tramp owners for some form of mutual co-operation, there is fortunately available the Tonnage Stabilisation Scheme . . . but in view of the desirability of support being forthcoming by the owners of foreign tonnage, this scheme may well need re-examination in the light of the substantial growth of shipping operating under flags of convenience."

As far as the ship-owners are concerned, the sting is in the second half of the sentence. The British Mercantile Marine is no longer in the dominant position it was 30 years ago—or even 10 years ago. Although the United Kingdom may obtain the co-operation of such maritime countries as Scandinavia, it will find it exceedingly difficult to come to a working agreement with foreign ship-owners using flags of convenience. The Greek tanker owners are expected to announce their own cartel arrangement soon to limit freight rates and as far as United Kingdom ship-owners are concerned, the prospect of two large groups trying to guess each other's rate policy might be even worse than no arrangement among themselves at all.

Turn of the Screw

The long-standing problem of the many different screw threads in common use was sharply high-lighted during the last war when the armed forces were faced with equipment issued by several countries. Since the matter was urgent for maintenance in the field a standard unified screw thread was produced and used. Since the war many attempts—particularly by I.C.I.—have been made to get this standard generally adopted for commercial use.

It is extremely doubtful if any standard thread would have an intrinsic advantage over any of the many types now in use. Its real benefit would lie in the interchangeability that would ensue, but for this to happen it would have to be universally accepted. The present Unified thread is based largely on American practice and makes no concessions to the metric system. Consequently the old controversy between the inch and the metre still remains, complicated by the recent adoption of the latter in the Far East. This is one of the points in the advice given by the British Electrical and Allied Manufacturers Association, originally issued as a letter to their members and now published as a booklet. (Publication No. 165.)

The use of a standard thread throughout the electrical manufacturing industry is a vital issue from the points of view of production, interchangeability, and servicing. For a variety of reasons the council of BEAMA do not consider the present time ripe for even a partial change to the Unified thread. They do make the point, however, that Unified threads should be used for equipment for the armed forces " when firmly demanded." They point out that the International Standards Organisation is considering recommendations for both an inch and a metric system with the Unified thread for the former. No one can tell which would have the greater potentiality for world-wide recognition. Since it is obviously in no-one's interest to have to change twice, it would seem that their advice to their members to continue using the standard British threads is the right plan to follow, always of course keeping an eye on the market for which the goods are intended.

Letters to the Editor

SEA DEFENCE WORKS

SIR, Mr. C. V. Bowles, in his letter published on page 259 of your issue of February 28, mentions the movement of shingle on Hurst Castle Spit and suggests that a breach in this spit might lead to a reduction in depth of the Needles Channel which would make passage difficult for large liners entering the Solent. We have recently examined this shingle formation and the groyning system now under construction between Milford-on-Sea and Hurst Castle to find out if the collapse of a portion of the Milford-on-Sea sea wall on August 17, 1957, was in any way due to the construction of these new groynes. We deduced that the damage to the sea wall was not connected with the new groyning system; in fact, the sea wall and the beach in front of it had been in a bad state of repair for some time and the occurrence of an unusually high tide accompanied by storm waves created high air pressures behind the wall and caused a collapse of the promenade for about 60 yards.

Hurst Spit has been moving steadily northwards for some time—since 1785 it has moved about 800 ft. The medium responsible for this movement is thought to be the motion of shingle during storm waves, when the waves pick up shingle from the face of the bank and push it over the top of the ridge; as a result the ridge moves backwards like a sand dune blown by wind. There is also a certain amount of shingle moving from west to east along the ridge, as this is the dominant direction of drift due to wave action. We are at present keeping this shingle spit under observation to see if the new groyning system will be successful in maintaining the spit in its present position.

Yours faithfully,
W. J. REID.

Hydraulics Research Station,
Howbery Park,
Wallingford,
Berkshire.
March 4, 1958.

STUDY PROJECTS

SIR, May I solicit the hospitality of your columns to draw attention to the value of " Study Projects " as a means of education and to ask for the assistance of educational and industrial organisations in providing technical material for students of this college? As in some other technical colleges, our three-year Higher National Diploma sandwich course in mechanical engineering deals in the second and final years with the subject Study Project for weekly periods of four and five hours respectively. The entrance requirement to the course is a good Ordinary National Certificate in Mechanical Engineering and the standard of the final-year examinations approximates to that of a pass degree.

The study project may take the form of either the investigation of a problem or the development of an idea submitted by industry or initiated in the college; or the complete design of, for example, a prime mover, a machine tool or other engineering equipment or apparatus; or the planning and layout of a production plant for a particular process or product.

Where possible, each student should have a specific problem to investigate for which he alone is responsible, but this problem will very properly form part of a related whole, worked on by other students. The project may be developed by using any of the established design techniques, such as the trial-and-error approach in one instance or, in another, by making an analytical approach; or an existing design or process may be examined and a critical survey made.

I should be very pleased to receive appropriate information, case histories, technical publications and other material which might be available from commercial and educational undertakings, as,

Continuing Letters to the Editor

in carrying out the above work, we have been handicapped by the lack of suitable background material for reference purposes.

I should like to point out that the resources of the college library are at the disposal of local schools and industry, and that any material received will be gratefully appreciated.

Yours faithfully,
D. CECIL MORGAN,
Principal.

Denbighshire Technical College,
Wrexham, Denbighshire.
March 3, 1958.

ENGINEERS AND THE GUILD

SIR, In your Weekly Survey of February 7 (page 162), under the paragraph heading "How the Engineer Lives," you refer more than once to "the professional engineer" in a context which conveys the impression that this definition is synonymous with membership of the Engineers' Guild, Limited, an association which is limited in more senses than one while it continues to exclude so many qualified professional engineers.

Many of us, who are eligible for membership of the Guild, who are from time to time solicited to join by an enthusiastic member or an energetic branch secretary, and who may in fact be in sympathy with some of the aims of the Guild, must remain outside so long as the council of the Guild maintain their parochial attitude in respect of the definition of a professional engineer.

Yours faithfully,
E. H. BATEMAN,
M.I.C.E., M.I.Struct.E., F.R.Ae.S.

Sandyridge,
Upper Bourne,
Farnham,
Surrey.
March 6, 1958.

ACCELERATED CURING TESTS ON CONCRETE

SIR, I was very pleased to see the article on the above topic by Mr. N. N. B. Ordman and Dr. N. G. Bondre in your issue of February 21 (p. 243), as it is the first published information showing the value of the accelerated test on site; all previous papers having been concerned with experimental work in my laboratory at Queen Mary College. Needless to say, I am very pleased that they are finding it so useful. Readers should note that the conditions in the oven and in the normal curing tank used by Port of London Authority are slightly different from those used in my laboratory, and the curves resulting are therefore slightly different from those published by me during 1957.

It is only quite recently that we have had the opportunity of comparing with our own ovens the oven used by another laboratory whose results did not comply with our curves, although apparently our technique was followed. It was found that whereas in our ovens, a thermometer in the standard position at the top indicated temperatures originally higher, and eventually some 5°C lower, than the temperature between the cubes, the other oven showed always a much lower temperature between cubes than on a similarly placed thermometer. We find that that oven has to be run at a temperature on the thermometer some 10°C higher than our own, in order to heat the cubes in a similar manner and obtain similar accelerated strengths.

If Mr. Ordman could supplement his account by further details of the oven type, and method of temperature measurement, it might prove to be very useful additional information for other potential users of the test.

As the section on the "Maturity Law" makes mention of steam curing, I would also like to utter a word of warning. Such information as I have from other experimenters who have tried to use steam or hot-water curing in place of oven curing, shows that neither can necessarily be relied on if the cement be changed; that neither gives such consistent results as oven curing with one cement; and that the curves so far published for oven curing will not serve, even though the heating cycle followed is apparently the same as that in the oven.

Yours faithfully,
J. W. H. KING,
Professor of Civil Engineering.

Queen Mary College,
University of London,
Mile End Road,
London, E.1.
March 10, 1958.

★ ★ ★

In our article describing the Foden dump-truck, which appeared on page 165 of our issue of February 7, it was stated that the tipping time was 65 s. This should have read "the tipping time was 8 s to an angle of 65°."

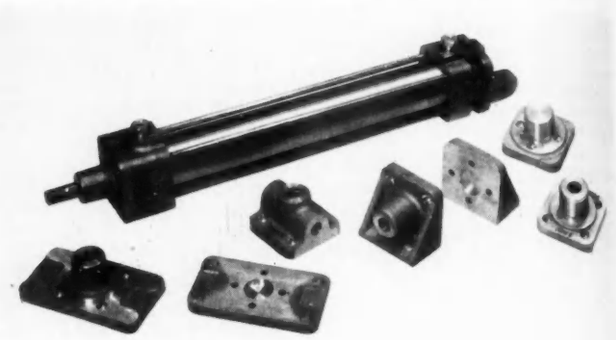
Plant and Equipment

BASIC CYLINDER UNITS

A new range of cylinder units has been introduced by Lang Pneumatic Limited, Wolverhampton. The range is developed about the Pneulang basic cylinder unit, which is available in several sizes with interchangeable adaptor plates. A robust design has been produced for use in a wide variety of applications such as jigs or attachments to machinery—in fact, anywhere that a normal air cylinder unit finds application. Its heavy construction would, however, debar its use in aircraft.

The cylinders are of tie-rod construction, with heavy-gauge barrel and stainless steel piston rods. The size of the rods has been increased throughout the range. For example, where a $1\frac{1}{2}$ in. bore cylinder formerly had a piston rod of $\frac{1}{4}$ in. diameter, the same cylinder in the new range has a rod of $\frac{1}{2}$ in. diameter. There are three bore sizes, eleven stroke sizes and eight different mountings. All are available "off the shelf," that is a total of 264 cylinders.

At a pressure of 80 lb/in², the efficiencies of the 3, $2\frac{1}{4}$, and $1\frac{1}{2}$ in. bore cylinders are 95, 94, and 92 per cent. Halving the pressure lowers the efficiency of the 3 in. cylinder to about 93 per cent. and the others to about 90 per cent. The recommended working pressure is 80 lb/in².



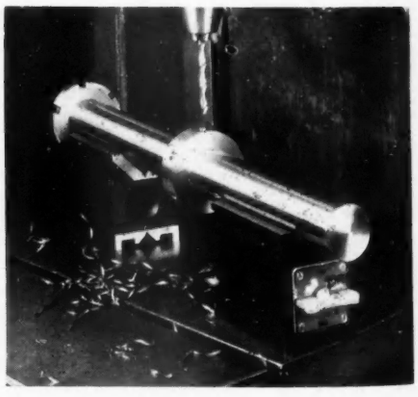
The basic cylinder unit is of tie-rod construction. A total variety of 264 cylinders are available by virtue of the different sizes and mountings.

An O-ring is fitted to the piston rod to prevent creep of air through the piston assembly. The piston cups and piston rod seals are of oil-resistant synthetic rubber, and a wiper seal is provided. Self-locking nuts are used to secure the pre-stressed tie rods of bright-drawn mild steel. For ease of installation, flats are machined on the ends of the piston rod. The piston, piston parts, and covers are brass stampings.

MAGNETIC V-BLOCK

A double V-block is the latest addition to the range of magnetic clamping equipment made by James Neill and Company (Sheffield), Limited, Sheffield, 11. The block is based on the company's "Alcomax" magnet, and is therefore self-contained, and independent of mains electric power. There are two V's, on opposite faces, the smaller accommodating $\frac{7}{8}$ in. diameter, while the larger will normally take up to $2\frac{5}{8}$ in. diameter, and can be machined out to accept slightly larger workpieces if required.

A switch at one end of the V-block controls the magnet. Both V's and the end of the block opposite to the switch are magnetised simultaneously. The block can thus be used with either V upwards, when the opposite face serves to clamp it magnetically to the machine table, or else on end, with the V's vertical. Either or both of the V's can then be used, and the block is clamped by its end to the machine table. V-faces and the block end are precision ground, square with each other, so the chuck can be used for accurate machining or gauging. The block is 4 in. long, $2\frac{3}{4}$ in. wide and $3\frac{3}{4}$ in. high, and is available either singly or in matched pairs. As it is fully sealed, coolant can be used in the normal manner, without affecting the block.



The Neill "Eclipse" magnetic chuck has two V's and can be used horizontally or vertically on end. When the V's are magnetised the block automatically clamps itself to the machine table.

Plant and Equipment

ELECTRIC BATCH-TYPE OVENS

A new range of electrically-heated industrial batch-type ovens for conducting such operations as baking, curing, drying, polymerising and stoving has now been introduced by Barlow-Whitney Limited, 2 Dorset-square, London, N.W.1. There are two basic types in the new standard range, designated series E.150 and E.300 and covering operating temperatures up to 150° and 300° C, respectively. Internal capacities are from 1 to 72 cu. ft.

The E.150 ovens, an example of which is shown in Fig. 1, are of robust all-steel double-skin construction, the cavity walls and door being fitted with non-sag pads ensuring insulation against heat losses. The heating elements are of the totally-enclosed metal-cased type operating at a black heat and rated for long service. Close temperature regulation is effected by an adjustable hydraulic thermostat fitted with a separate neon indicator. All the control gear, except for the door thermometer, is housed in the base in the small bench-type ovens. On the larger ovens the controls are situated in a steel case fitted on a side wall.

The E.150 ovens are arranged with natural ventilation for the disposal of moisture or fumes but they can be supplied with a motor-driven fan to stimulate the circulation of the air. Work trays of strong wire mesh or expanded metal are provided, and runners are arranged in the oven interior for their accommodation.

The E.300 ovens, an example of which is shown in Fig. 2, are for use at temperatures of up to 300° C, and are of somewhat heavier construction and more highly insulated than those of the E.150 type. Although available with natural ventilation, the ovens chiefly in demand by industrial users are those fitted with forced circulation with either horizontal air flow (the H.A.F. type) or vertical air flow (V.A.F. type), the choice being determined by the nature of the work to be processed. Both systems incorporate a motor-driven fan housed in the oven roof, providing up to ten changes of air per minute thus ensuring uniform temperature conditions and rapid heat transfer. The air flow is adjustable from a full throughput of fresh air to partial or total recirculation as requirements dictate. An electric interlock ensures that the heaters are only in circuit when the fan is running.

Fig. 1 Standard electric oven, type E.150, for operating at temperatures of up to 150° C, heated by totally-enclosed metal-cased elements.

Fig. 2 Forced-circulation electric oven of the E.300 H.A.F. type with horizontal air flow provided by a fan in the roof.

The temperature of the E.300 forced-circulation ovens is automatically controlled within close limits by means of a dial indicator-regulator which, together with a suitable relay, signal lamp, heat switch and fan-motor starter, are housed in a control box on the side of the oven. A safety thermostat which limits the temperature and thus protects both the charge and the heating elements should the main controller fail to function, may also be provided. Recorders, programme controllers, process timers and other devices can be furnished to suit requirements.

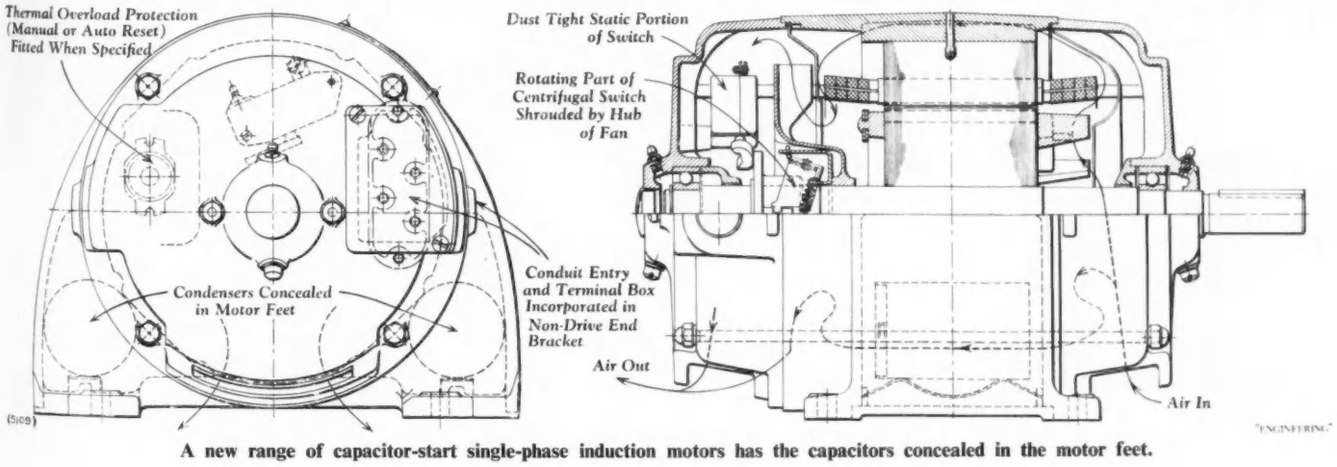
Optional features include the incorporation of explosion reliefs when ovens are required for processes which release inflammable gases giving rise to explosive hazards. Moreover, a special ventilation arrangement can be incorporated which prevents the escape of toxic fumes into the workshop.

INDUCTION MOTOR FOR FARMERS

Newman Industries Limited, Yate, Bristol, are making a new range of single-phase motors. Electrification in rural areas is proceeding rapidly, and Mr. Hedley Newman, assistant managing director, explained the introduction of the new range as follows: " We have set about offering the farmer a motor as robust as its three-phase counterpart. We do not claim to have altered any of the laws of physics—the relation between torque and current is still the same ! But we do claim to have tackled the job from first principles in order to provide a motor designed exclusively for single-phase duty—and we have built the condensers into the body of the motor—out of harm's way."

The motor is drip-proof enclosed, and two capacitors are fitted into the feet. Ultimately the range will be from ½ to 5 h.p. in two, four, and six-pole speeds; but the sizes immediately available are 1, 1½, 2 and 3 h.p.—four-pole for 50 or 60 c/s supplies. A small centrifugal switch is concealed inside the non-drive end bracket together with the terminal block. A totally enclosed, dust-tight moulded housing containing silver contacts makes up the static part of the switch. This is mounted in the end bracket. The rotating part of the switch is fitted to the hub of the fan, so that it is shrouded by the fan itself from dust drawn into the motor.

For ventilation, air is drawn in at the underside of the drive end bracket, passed axially through the motor and exhausted at the underside of the non-drive end bracket. A pressed-steel baffle is arranged to exhaust the air from the motor in front of the fan. The diagram shows the air circuit and the general construction of the motor.


Thermal Overload Protection (Manual or Auto Reset) Fitted When Specified
Condensers Concealed in Motor Feet
Dust Tight Static Portion of Switch
Rotating Part of Centrifugal Switch Shrouded by Hub of Fan
Conduit Entry and Terminal Box Incorporated in Non-Drive End Bracket
Air Out
Air In
(SIGS)
"ENGINEERING"

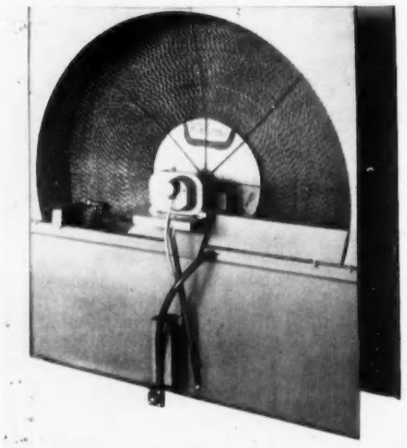
A new range of capacitor-start single-phase induction motors has the capacitors concealed in the motor feet.

Continuing **Plant and Equipment**

AIR CLEANING WITH LOW MAINTENANCE

Two systems of air cleaning and filtration new to the United Kingdom are now being made under licence from the Farr Company, Los Angeles, California, by Intermit Limited, Bradford-street, Birmingham, 5, namely, Far-Air viscous impingement filters, and Rotonamic air and gas-cleaning panels, which are in effect static centrifuges.

Far-Air filters work on the principle that airborne solids tend to travel in a straight line while the air-stream in which they are carried can be led to travel a devious route. Each Far-Air filter therefore consists of alternate strips of herring-bone-crimped wire cloth or gauze, sandwiched between flat uncrimped strips of wire gauze, 2 in. or 4 in. wide, assembled into pressed metal frames of appropriate thickness, with the lengths and breadths corresponding to a range of standard sizes. An assembly of these single filters can be held in an interlocking frame and thus comprise a filter bank of large area through which atmospheric air can be drawn by fans. Each filter is treated, before use, with a specially developed mineral oil of a specification which produces high wicking and adhesive tendencies without odour. A special application of the principle is illustrated in Fig. 1, which shows an evaporator cooler constructed with crimped metal of the type used in Far-Air viscous impingement filters.



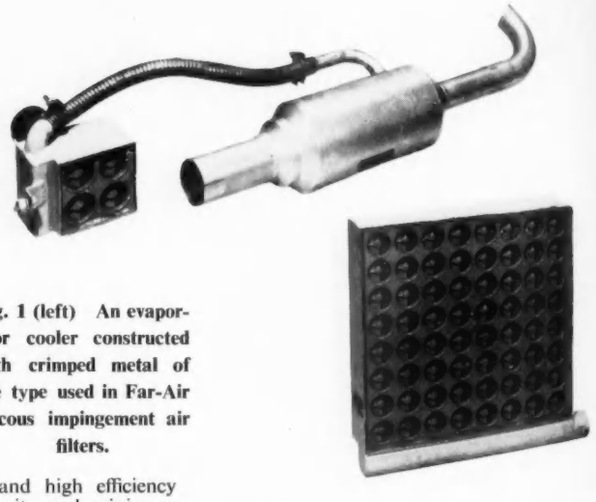


Fig. 1 (left) An evaporator cooler constructed with crimped metal of the type used in Far-Air viscous impingement air filters.

When airborne particles, carried with the air into the Far-Air filter labyrinth, impinge on the adhesive oil, they remain trapped, and the air is clean by the time it traverses the filter. A 2 in. thickness of Far-Air filter is normally sufficient, and the 4 in. thick filters are specified for those atmospheres only where the proportion of solid particles is abnormally high.

Cellulose tissue (" paper ") filters are also marketed by Intermit Limited, which can be used in conjunction with the metal fabric filters, fitted into the same frames, to give exceptionally complete removal of solids in the range up to 10 microns diameter. To protect reciprocating prime movers and air compressors against abrasion, circular filters which operate on the labyrinth principle have been proved to lengthen the life and maintain the peak performance of, for example, Diesel engines both in railway and road transport use. Another filter, the Far-Air D/C filter, uses glass fibre media, compressed upon installation from a 2 in. thickness to a 1 in. thickness. This is intended for installations which must be simple to maintain and may require different media under different operating conditions. It is also applicable for use in areas where the filter-cleaning service operated by Intermit Limited is not easily available.

The present Far-Air filters take only 15 seconds each to remove and replace, and, it is claimed, require replacing far less frequently than conventional fabric and paper filters. At the Hotel Leofric, Coventry, a set of four Far-Air filter banks has replaced the previous inefficient " throw-away " cloth filters. The original cloth filters took 20 minutes each to remove and replace, and there were hundreds of them. This has resulted, it is stated, in a saving in filter cost of 82 per cent per annum (upwards of £700).

For purposes of book-keeping, the life of Far-Air filters has been estimated as 10 years, though in fact there are no moving parts and consequently nothing to wear out. The initial outlay and installation of these filters, with some spares (for use while others are being laundered) is therefore the only outlay. Intermit Limited are now setting up servicing depots strategically placed throughout the country for the collection, cleansing, and re-oiling of soiled Far-Air filters. They also manufacture washing plant of various sizes for large concerns where the installation is justified. An automatic type of Far-Air filter installation which incorporates cleaning and re-oiling facilities for periodical operation *in situ* is also available. Dry-type automatic filtration is provided for by the Far-Air Roll-Kleen filter, which, it is claimed, combines fully automatic operation and high efficiency with large dirt-holding capacity and minimum maintenance.

The other system, the Rotonamic air cleaner (Fig. 2), is simple, of high efficiency and, having no moving parts, it needs no maintenance apart from the emptying of collected solids from a hopper. Helical blades mounted in a panel give the air a whirling motion in its passage through the panel. The sudden acceleration and whirling moment centrifuge the solids out of the air-stream into comparatively still air, where the solids fall out of suspension and are aspirated away for collection or other disposal. Rotonamic air filtration panels, in many cases, can be incorporated in existing dust-removal apparatus as required by regulations under the Factories Act.

Both the Far-Air " labyrinth " principle and the Rotonamic centrifuge principle are clearly adaptable to many industrial applications apart from the obvious purpose of air cleaning; for instance, there are the possibilities of segregating desired small particles of talc, cement, plaster, and other marketable dusts from larger particles which can be returned for re-processing. Other applications of the principle include a Far-Air grease eliminator, and an evaporative cooler of crimped metal gauze. Both systems are available in a variety of metals—for example, stainless steel—which render them suitable for use in corrosive atmospheres.

Fig. 2 At the top is a Rotonamic assembly with flexible hose to use engine exhaust as a dust aspirator. Below can be seen a Rotonamic filter panel. Solid particles removed from air or other gases drawn through this panel are aspirated through the tubular section at the base of the panel.

MAKING GAS FROM OIL OR LOW-GRADE COAL

What is described as a completely new method of gas production is to be employed in a plant to cost £2 million, at Partington near Manchester. The North Western Gas Board, acting for the Gas Council, has signed the contract for the plant which is to be built and equipped by Humphreys and Glasgow Limited, 22 Carlisle-place, London, S.W.1. The gasification system will comprise the production and purification of hydrogen at a purity in excess of 90 per cent by the gasification of oil, and at a later stage coal, at a pressure of 400 lb per sq. in., with oxygen and steam at a temperature of approximately 2,500° F (1,370° C). The hydrogen will be used for the production of a rich gas by the hydrogenation of further oil or coal to produce gas having a calorific value of about 600 B.T.U. per cu. ft. The rich gas is then diluted to the required calorific value by the addition of nitrogen. The process employed for the production of hydrogen is that of the Texaco Development Corporation, for which Humphreys and Glasgow are licensed contractors.

A wide variety of different grades of oil can be utilised, taking advantage of fluctuations in the price of oil-refinery by-products. Later, as already indicated, it is intended that low-grade coal will take the place of the oil, thus providing an outlet for a fuel of limited value.

The installation at Partington will have a capacity for producing 7,500,000 cu. ft of gas a day and its main object is to hasten the full-scale development of the new process, which was first envisaged by Dr. F. J. Dent, director of the Gas Council's Midland Research Station at Solihull, Birmingham, and it is based on experimental work conducted by his research team over many years.

The Partington plant is planned to be in operation at the beginning of 1960.

Advantages of the new process are expected to be cheapness, flexibility in raw materials, low toxicity of the gas, freedom from sulphur compounds and availability at high pressure. The high pressure will allow the gas to be transmitted economically over long distances.

The gas made in the Partington demonstration plant will cost roughly the same as that produced by conventional methods, but for larger plants considerable reductions in both capital and operating expenditure, it is stated, would cut costs materially.

HIGH STRENGTH EYES IN WIRE ROPES

The Superloop is a wire-rope eye that has been developed by British Ropes Limited, Doncaster, for wire ropes. The main claims for it are its strength and the small size of the gripping sleeve. The method is particularly suitable for the company's Blue Strand preformed ropes. It is based on the Flemish eye—itself a very strong form of splicing.

Blue Strand preformed rope differs from ordinary ropes in that the strands are first formed to a helical shape so that they lie naturally in the rope and there is no tendency for them to spring apart when the rope is cut. To make the Superloop, three strands are unlaid and the remaining three and the core turned back to form a loop, catching the end under the three loose ones. These latter are then relaid, the core cut off and the ends of all strands laid into the interstices of the main rope. The sleeve is then slid over the ends and clenched in a press. Fig. 1 shows the eye being formed, and Fig. 2 the completed loop.

The sleeve, of a low-carbon ductile alloy, is initially formed to have a barrelled portion to take the ends of the loop so that they are not crushed during the clenching, and so that the whole grip is taken by the rope itself. The rope end of the sleeve is tapered externally to give a smooth run out. Clenching is carried out in a four-segment die, and requires only a comparatively low pressure. There are two stages: first a moderate compression followed by a 90° turn of the sleeve, and then the operation is completed by applying full pressure. The flashes formed during compression later are ground off. At present the range of rope sizes that can be made with Superloop is limited to between $\frac{5}{16}$ in. diam. and $2\frac{1}{4}$ in. diam. but dies and sleeves for larger sizes will shortly be available. On the sleeve is stamped the identification number and other information. A coat of blue lacquer indicates the type.

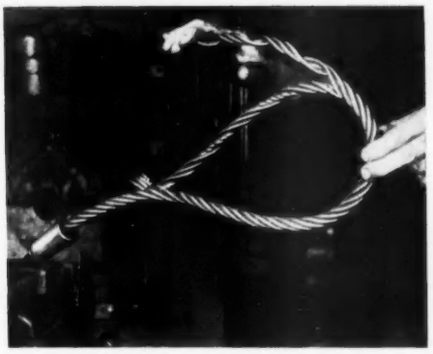


Fig. 1 A Flemish eye is first formed in the rope and then the sleeve is slid over the loose ends.

Fig. 2 The sleeve is compressed in a die to give the loop a strength near that of the rope.

During a recent demonstration at the company's Charlton works, loops of rope made were tested to destruction in a tensile test machine; in all cases failure occurred at loads not less than 90 per cent. of the breaking load of the rope itself, even after deliberate damage of the sleeve by hammering.

An additional item that can be fitted to the loop is a malleable iron stirrup, as shown in Fig. 2, instead of the solid thimble often used. The claims for this are that the loop is protected from wear while giving the same ease of reeving without the weight of the solid thimble, that the eye is more flexible and that it can be replaced very easily at any time.

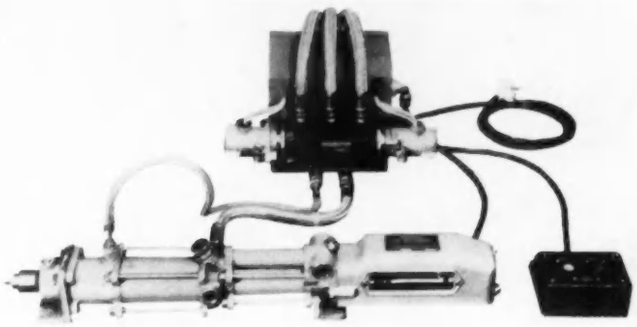
AUTOMATIC DRILL UNIT

The "Woodpecker" drill unit, introduced by the Maxam Division, Climax Rock Drill and Engineering Works, Limited, Carn Brea, Cornwall, is a combined compressed-air operated ½ in. drill and hydraulic feed, and can be arranged to work in one of several ways, according to requirements.

The spindle, which carries a self-centring drill chuck, runs at 2400 rev/min in the standard model, but alternative gearboxes are available, for spindle speeds of 540, 970, 4000 and 6000 rev/min. Two standard units are produced, one with a stroke of 2 in., and the other with a 4 in. stroke. Control is through a "Maxam" four-way double solenoid-operated valve, which is normally supplied to work on 12 volt alternating current, but can be wound for most standard alternating and direct current voltages. A suitable relay, which can be supplied with the unit is also necessary. The unit can be mounted in any position ranging from the horizontal to vertical.

In operation, the hydraulic feed unit, which has an infinitely-variable speed, advances the drill rapidly until the work is contacted, and then slows automatically to the pre-set controlled rate of feed. Drilling continues to a pre-set depth, when the drill is retracted to clear chips or swarf from the hole, and then re-advances rapidly, contacts the bottom of the hole and once more reduces the speed to the set drilling rate. On the return stroke the drill ceases to rotate and only starts again when the forward stroke begins; air consumption is thus kept to a minimum. This "pecking" action continues until the required depth of hole is drilled, when the unit retracts rapidly and rotation stops.

The depth of peck is infinitely variable, and the number of pecks depends on the pre-set depth of peck and the depth of hole being drilled. If required, the drill can be made to rotate slowly during the return stroke and in its re-set position.

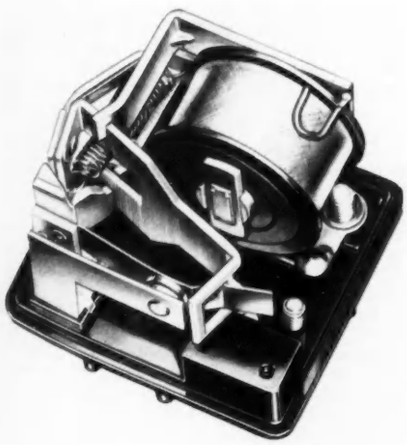


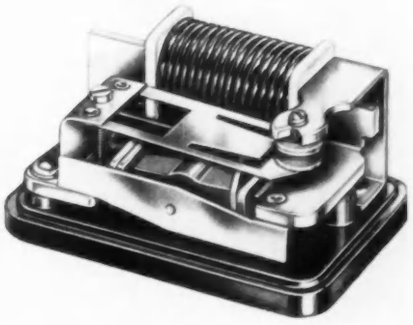
Climax "Woodpecker" air/hydraulic drill unit arranged with starter, relays, and transformer for demonstration purposes. The various parts can be arranged to suit particular applications.

STARTING SMALL MOTORS

A relay designed as an alternative to a centrifugal switch in a.c. fractional horse-power motors is made by Magnetic Devices Limited, Newmarket, Suffolk. The unit, Series 311, is shown on the left. The relay is connected in series with the motor and is adjusted to disconnect the start winding when the motor is up to speed. The single-pole normally-open contacts are operated by a small current differential. The coils can be wound for 0·5—10A.

On the right is shown a Series 310 relay, made by the same company as an alternative to a centrifugal switch for starting single-phase capacitor-start motors. The contact arrangement is single-pole normally-closed. Operation is by a wide coil-voltage differential. The relay winding is connected across the start winding of the motor; as the motor speed increases the potential difference across the start winding, and therefore across the relay coil, also increases, eventually causing the relay to operate and disconnect the start winding. The induced voltage in the start winding continues to energise the relay down to the stalling speed of the motor.





Continuing **Plant and Equipment**

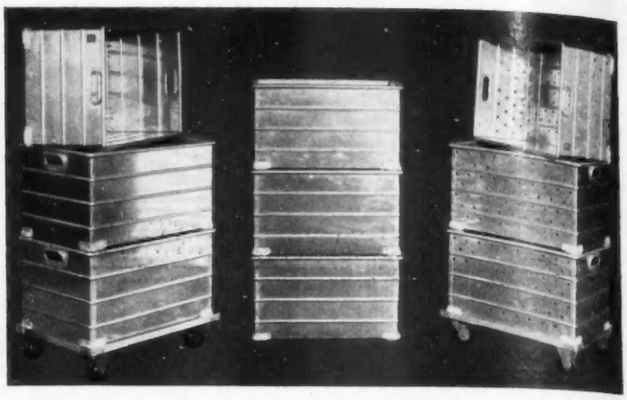
ALUMINIUM CONTAINERS

Aluminium containers for general use inside and outside the factory were shown at a recent exhibition. Constructed by the Light Alloy Construction Company, Limited, Mowden Hall, Darlington, County Durham, they are made of a special high strength alloy developed by the British Aluminium Company, Limited. Some of the types available are shown in the accompanying illustration.

Of riveted construction the containers can be made with the beading and handles either inside or outside to suit requirements. They are made in a range of standard sizes but any size can be produced at only the extra cost of the drawings needed. Thus it is possible to order only two or three containers, without a heavy extra charge, even when not of an existing size. They are formed on a single press which carries out all operations pneumatically, and is virtually silent in operation.

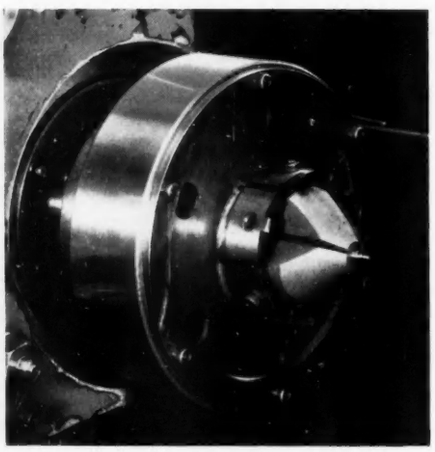
The containers may be of the nesting type as shown in the illustration or else may have swinging arms that come over the top and on which another container can stand. When these "Conibins," as they are called, are empty the arms can be swung back and then the containers will nest one within the other. A flat wheeled trolley is also available so that a stack of containers can be easily moved from place to place. Another product of the firm is the "Tracon" collapsible container described in ENGINEERING, page 279, vol. 183 (March 1, 1957).

The riveted construction allows a damaged panel to be replaced at a minimum cost and the alloy used is heat toughened. One of the Hanboxes shown will easily bear the weight of a man standing on the bottom. The carrying capacity of the standard grade is of the order of 2 cwt.



The Hanbox is only one of the many types of "Lacon" light-alloy containers suitable for general handling.

PRECISION CHUCKING WITH SIMPLICITY



Simplicity and repetitive accuracy are the main features of the Integral hydrostatic chuck, which is available in a range of sizes and can be adapted to fit any machine tool.

Designed originally for use in their own factory, the "Everac" hydrostatic chuck has now been placed on the market by Integral, Limited, Birmingham-road, Wolverhampton. It is of the diaphragm type, simple to fit to a machine, easy to operate, to a high degree of accuracy.

There are two diaphragms, a main or outer diaphragm which carries the split chucking ring on its external face, and an inner diaphragm which forms one wall of an internal chamber filled with hydraulic fluid. A small-diameter cylinder containing a sliding piston communicates with the fluid chamber, and external means are provided for moving the piston. When the piston is depressed the consequent rise in pressure acts on the inner diaphragm, deflecting it outwards. A central boss on the inner diaphragm then presses on the outer diaphragm, and causes a small radial outwards movement of the six segments of the chucking ring and of any jaw pads attached to them. On release of the piston the two diaphragms tend to return to the unloaded position, and the jaw pads grip any suitably-sized object placed between them. Hydrostatic pressure is thus used only for opening the chuck; the gripping force is derived from the elasticity of the outer diaphragm. Up to the top limit of grip for which the diaphragm is designed, the force can be varied as required by adjusting the internal diameter of the jaw pads.

Because the chuck is only opened by pressure there is no possibility of its releasing the workpiece accidentally, and as there are no pipe connections control is very simple. Hydrostatic pressure operation also gives a greater mechanical advantage than any other method—it is easy to obtain a ratio of 140 to 1 between the load on the piston and the load on the chuck jaws, which further simplifies the control arrangements. In its simplest form the chuck has a single piston, located on the periphery, which is depressed by finger pressure. Alternatively, the piston can be located axially at the rear of the chuck. It is then depressed by a push rod, which can be operated manually or by remote control. Another version of the chuck, shown in the illustration, has three pistons, which are operated by a knurled cam ring.

The construction of the chuck enables it to be used for very accurate work, and it is not intended for general first-operation machining, though it can be used on any components, such as small die-castings, which have an accurate chucking diameter. It is possible for a semi-skilled operator to remove a workpiece from the chuck, re-insert it and carry out another machining operation with concentricity to within $\pm$ 0·000 08 in. Given normal setting-up and an accurately-ground chucking diameter, repetitive concentricity can be guaranteed. The accuracy required on the component for chucking depends, of course, on the size of the component itself and on the finished accuracy desired. In a chuck taking a component 2¼ in. in diameter the recommended jaw opening is 0·004 in. to 0·005 in., and the chucking size of the component should be to a tolerance of 0·000 2 in. to 0·003 in.

At present the chuck is made in a size range which will accommodate workpieces from the nominal zero to 4½ in. diameter, and with a positive grip up to 2¼ tons. Other sizes and types, variations to suit specialised machine tools and automatic production lines are to be produced. The chuck can be supplied with any required number of sets of jaw pads to suit particular workpieces, or these parts can be made and ground by the chuck users. A range of setting rings is available, to enable the jaws to be adjusted to any required pressure up to the maximum, for any size within the range. Simple adaptors make it possible to fit the chuck to any type of machine tool, or to use it for such work as gauging, checking and testing.

INTERNAL GROOVING

The cutting of grooves in bores is simplified and speeded up by the "Truarc" grooving tool which has been introduced by Geo. Salter and Company, Limited, West Bromwich. Designed primarily for cutting grooves for retaining rings, the tool is also suitable for general-purpose grooving, and can be employed for other operations such as chamfering, facing or undercutting for screw-threads.

The tool can be used in various types of machine, such as drilling machines, capstan or centre lathes, milling machines or automatics, or in portable drills. It will operate either when it is rotating and the workpiece is stationary, or vice versa.

As the machine spindle is moved towards the work a bush in the tool head, or a bottom adapter, leads into the bore of the hole to locate the cutter ready for cutting the required groove. Continuing the downward pressure of the machine spindle causes the actual cutting tool to move out from its housed position. This movement continues, in an eccentric swing, until the required depth of groove is cut, when an internal stop action within the tool prevents the spindle from moving further. As the pressure on the spindle is relieved the cutter retracts automatically, and the tool can then be withdrawn from the bore. The grooving operation is so simple that unskilled labour can be used without sacrificing accuracy.

A range of five sizes is available, covering bore diameters from $\frac{3}{8}$ in. to 4 in. The actual sizes in each tool in the range are: $\frac{3}{8}$ to $\frac{5}{8}$ in., $\frac{5}{8}$ to 0·900 in., 0·900 to $1\frac{3}{8}$ in., $1\frac{3}{8}$ to $2\frac{3}{8}$ in., $2\frac{3}{8}$ to 4 in.

The Salter "Truarc" grooving tool enables accurate internal grooving to be done by unskilled labour.

The Human Element

Arbitrators' Quandary

The award of a 3 per cent increase in wage rates to the 11,000 clerical workers employed by the British Broadcasting Corporation is the first since the publication of the Cohen report. Almost inevitably, therefore, there will be a tendency to look upon it as a precedent for forthcoming industrial decisions. In many ways it will be considered as reassuring evidence that arbitrators carry out their task in an objective manner and that their attitude will not be solely influenced by Mr. Thorneycroft's appeal last autumn to take into account the danger of inflation. On the other hand, the atmosphere surrounding wage disputes has changed a great deal in the past few months. Rising unemployment and falling commodity prices may have influenced a decision which would have appeared foolhardy at an earlier date.

The Cohen Council recommended that arbitrators should take into account the supply and demand for labour in the industry under review as well as the general economic situation. For some industries which have been losing labour over a long period this is of considerable importance. On the whole, therefore, the task of arbitrators would be much simplified if they had not to concern themselves with how much to award on the basis of the cost-of-living index. Lord Chandos' suggestion of an agreed automatic scale would achieve just this, to the benefit of all concerned. Ideally, however, arbitrators should concentrate on the specific problems of particular industries.

Blackening the Market

Collective bargaining has many advantages, one of the main ones being that both sides of industry are in favour of it. It has certain pitfalls, however. The most important of these is that it tends to make the labour market insensitive to demand and supply. This again is a not unattractive idea to employers and trade unions under certain conditions.

The British Employers' Confederation last week issued a request to industry not to pay wages in excess of the rates negotiated in collective bargaining. There is much to be said, of course, for this point of view. It has the great merit of trying to prevent the unscrupulous from benefiting from other people's willingness to refrain from action which would break up a general agreement. On the other hand, the stress which the labour market feels in certain sections is an indication that labour resources are trying to move in a certain direction and the pressure helps to bring that change about. In the same way, a black market may be deplored in times of control but it is a vital indicator of demand and supply. It is doubtful if payment of wages above a certain level agreed in negotiation between both sides of industry can be completely watertight. If it ever became so, the negotiators themselves would have lost one of their measuring rods. In this imperfect world, only 90 per cent effectiveness may be attainable and that may be no bad figure on general grounds either.

Selling the Cohen Council

Last week the Government intimated that the Cohen Council is to continue in existence and make periodic reports on the state of the nation. This will meet with a good deal of approval (despite much rumbustious criticism) for if the idea behind the Council has any value it is that reports from an impartial body shall be made at intervals and that they should be something of a running commentary to be kept quite separate and distinct from Government policy.

Meanwhile, a certain amount of recrimination has developed about the first survey. Sir Colin Anderson, the retiring President of the British Employers' Confederation, has taken the T.U.C. to task for its public remarks on the report. There is a good deal in what he said about the T.U.C.'s partisan approach, but anyone connected with the B.E.C. is the last person in the world to say it if the object is to influence the T.U.C. The idea of an impartial committee giving a running commentary on the economy is a very novel one to both sides of industry and it might have taken only a slight modification of the Council's views on certain subjects for the B.E.C. to be alongside the T.U.C.

If the idea of the Cohen Council is to find general acceptance, and it will take some time, there will have to be silence in public about other people's reactions. If this does not happen, the Council will cease to exist (which a number of vested interests would not consider a tragedy) or its composition and its views will change with each Government and it will become a tool of propaganda. There are enough of these already.

Time or Piece Rates

The maintenance men's strike at the car and tractor plants of the Standard Motor Company threw into relief the conflicting nature of pay by the hour and pay by results. At times of high activity, as is now the case in the motor industry, workers on piece rates do very much better than those on time rates. Hence the dissatisfaction of the maintenance men at Standard's. The 500 men involved at these plants had for two weeks banned overtime in protest against the management's refusal to concede a wage claim, although their rates of pay were substantially above the average for the district. Similar moves were believed imminent at Austin's Longbridge factory, and there have been a number of stoppages at some of B.M.C.'s plants by internal transport workers over the same issue.

Management in the industry is now thinking more and more in terms of a permanent solution to this problem. Two years ago Vauxhall Motors, following the general practice in the United States, abolished payment by results and put all wage earners on to an hourly basis. The results are said to have been excellent, and other companies might do the same with advantage. Another possible solution is to associate maintenance and service workers more closely with the rate of production through the payment of bonuses. American experience suggests, however, that in an industry traditionally subject to violent fluctuations in output, payment by the hour is best. The speed of work is largely governed by the speed of the machines or the conveyors, which is determined by the management. Too much depends on factors beyond the control of the workers themselves to warrant payment by results.

Towards Dockside Stability

For the first time since the war there is a substantial surplus of labour in the docks and it is increasing. In consequence new attitudes are emerging to these two factors which have, in the eyes of the dockers, the most direct bearing upon the number for whom work is available: overtime and machines. Members of the National Dock Labour Board's "pool" at the Royal and West India group of docks decided to ban overtime in order to spread the work available among the registered workers.

The Dock Labour Board have done what they could to reduce numbers by suspending recruitment, and have succeeded in lowering them from 80,000 to 76,000 during the past twelve months. The trend is strongly towards fewer workers for each ton of cargo handled, and mechanisation has increased faster than the volume of work. So far the militant workers have limited their demands (in addition to the ban on overtime) to two: an increase in the "fall-back rate," which is paid when no work is available, and a reduction in the number of times the men have to report to qualify from two to one. This search for security is slowly spreading, understandably enough, and the situation will need tactful as well as sympathetic handling.

Feudal Inheritance

An article, "The British Foreman," in the annual for supervisors called *Foreman* (No. 6) has been written by a Canadian. It dwells at some length on the reluctance of a man (the article is written as the story of a particular foreman) to accept promotion because he will be moving away from his social group—going up in the world and getting out of his class. To the writer, class consciousness in England is clearly a stumbling block to a man's willingness to better himself.

Class distinction is a wide subject but it has two relevant aspects in the problem of a man and his work. It can certainly reduce enterprise among those who are blessed with it in only limited quantities, and it can increase a man's loyalty to his group. In other words, group loyalties are of particular significance in British industry. The British worker is suspicious about capital and management, not because he knows his Marx (for he certainly does not) but because he is antagonistic to what to him is the "boss class" and is strongly loyal to his own. He is at the same time repelled from one and attracted to the other. He who said the workers of the world had nothing to lose but their chains had never understood the British working man.

Clearing the Head

One of the clearer thinkers in the Government, Sir Edward Boyle, Parliamentary Under-Secretary to the Ministry of Education, argued a few days ago in favour of scientific training as a way to clear thinking. He told the annual conference of the National Association of Heads of Secondary Technical Schools that "you can bamboozle an argument, but you can't bamboozle a piece of wood, or a quadratic equation." Hence it was high time the general educational value of technical studies was recognised.

Sir Edward is probably right, though some will argue that any mental exertion is good training for the person who is able and willing to think at all. In the past, scientific studies have not been a very good passport to the board rooms of industry, but it could be argued with equal force that occupants of board rooms relied upon intuition and inherited managerial ability rather than clear thinking. Now management has gone all scientific. Facts are gathered, barometers of this and that are permanently affixed to the walls and deductive thinking is at a premium. Management by reasoning has doubtless come to stay, and the scientist is getting a foot in the door.

Yet they were engineering students who, at Liverpool recently, threw various missiles at Mr. Tommy Steele performing before spastic children. Presumably scientific studies also qualify the beneficiaries to be self-appointed arbiters of public taste. Their behaviour, on the other hand, would suggest that taste and clear thinking were not in fact products of the same training. Evidently we are not yet ready for what Lord Hailsham has disparagingly called "governmen by university resolution."

Special Article

TURBO-ALTERNATORS REACH 275 MW

The announcement that a contract has been placed with the English Electric Company for two generating sets of 275 MW capacity, for the projected station at Blyth B, serves once again to show the enormous strides that have been made in generating plant since the war. In 1948 the first sets of 60 MW were commissioned, to be followed by 100 MW sets in 1952, 120 MW in 1955 and 200 MW, also in 1955. With sets of 275 MW the limit is being reached—not through technical or constructional problems but simply and solely because the stators for sets of this size (or a little larger) represent the maximum load that can be carried on the roads of this country, namely about 150 tons. Although sets of 550 MW are contemplated (the contract for two boilers of this size has indeed been placed with International Combustion, as recorded in our issue of February 28) these will be made up of twin-shaft cross-compound units each of 275 MW. The English Electric Company's claim, therefore, that their 275 MW units are the largest single-shaft sets would seem to be justified.

It has been for both technical and economic reasons that the policy of the Electricity Authority since the war has been one of large single-unit sets rather than many small ones. As the size of a generating plant increases its output increases at a faster rate than its losses: a large alternator is a more efficient machine than a small one. Similarly as turbine size increases the flow characteristics improve, so once again a larger unit is more efficient. This emphasis on efficiency can be more readily appreciated when it is remembered that an increase of 0·5 per cent. in the performance of all the generating stations in this country represents a saving in coal of almost 1 million tons per annum. Even with the low grade coals that it is now possible to burn in power stations, this is no mean financial saving. The present best efficiency from a C.E.G.B. station (Castle Donington) is 31·53 per cent.: English Electric quote a figure of 35 per cent. overall for their sets at Blyth B.

The use of unit sets also effects savings in other directions. The size of building needed is, relatively, much less—Skelton Grange A of 360 MW total output from six sets and nine boilers requires 28·6 cu. ft per kW installed, while the projected 1100 MW station at Thorpe Marsh (two 550 MW sets and two boilers) will only occupy 12·6 cu. ft per kW. The saving in cost attendant on the reduction in the building size, together with the time that is also saved during the construction period, accounts for the fact that total costs have been brought back almost to the 1948 figure of £50 per kW.

In their report for the year ended March, 1957, the Central Electricity Authority recorded the approval of 275 MW sets for the 1962 programme. At the same time a 550 MW unit, with a two-line turbine was proposed for 1963. The former was expected to be a direct development of the existing 200 MW designs; but many new problems would arise with the latter. English Electric are of the opinion that their 275 MW machines could be increased to 300 MW without increase in frame size. Direct hydrogen cooling (that is with the gas passing through hollow conductors) will be employed for both rotor and stator windings.

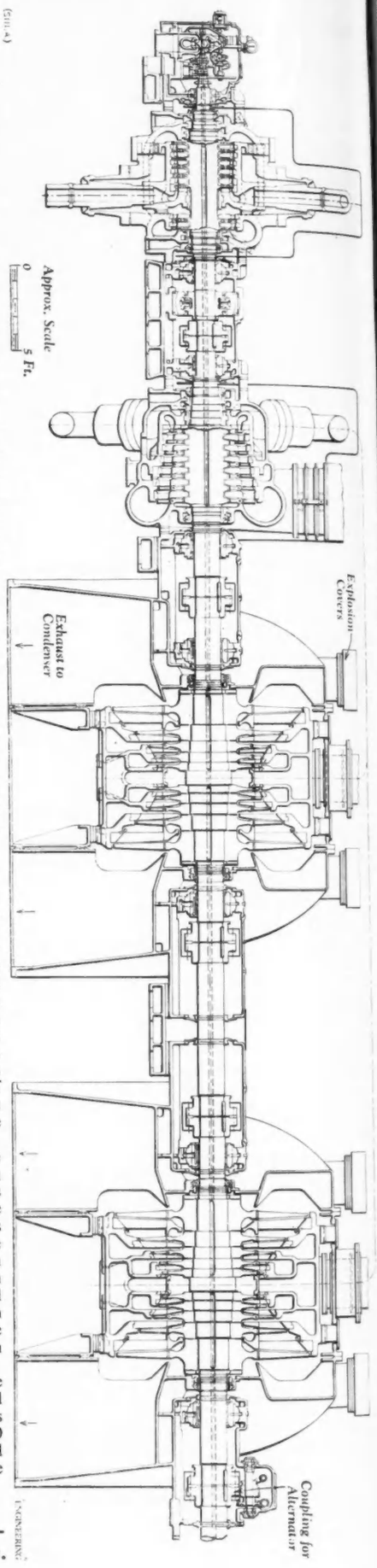
The prototype sets using direct hydrogen cooling are the 120 MW units being supplied by the English Electric to Willington A station. The use of some special cooling system is dictated by weight considerations as a solid stator for a 100 MW set almost reaches the limit of 150 tons. In the English Electric system the hydrogen passes through hollow conductors in the rotor and slots in the stator. Other cooling systems have been developed by the General Electric Company and Metropolitan-Vickers, who both use water cooling of the stator (as being the part which needs most to be reduced in weight), the water passing through hollow conductors. In both cases the rotor is conventionally cooled by hydrogen passing over it. Water offers the advantage of better heat transfer than gas and therefore of higher ratings for the same conductor size. G.E.C. also use water cooled bushes. The Metropolitan-Vickers prototype machine (rated at 30 MW) went into service last year at Bold A station and is the type for 200 MW sets at Willington B and some at West Thurrock (the first were supplied by C. A. Parsons). Against the better conductivity of water must be set the complexity of two cooling systems (the cooling of the rotor with water still offers many problems) and the fact that it is possible to use thinner walled conductors with gas, as an accidental leakage would not be so disastrous.

According to English Electric figures, the use of direct gas cooling can reduce the stator weight to about 85 per cent. of the equivalent solid conductor machine and the rotor to about 65 per cent. However, the increase in current obtained gives rise to greater armature reactance and so the air gap is increased to between four and five inches. A correspondingly greater load is also thrown on the associated switch gear. At the same time the stray load due to leakage currents can give rise to increased local heating; to check danger points the sets for Willington A were fitted with 300 thermocouples.

The English Electric sets for Blyth B have three-cylinder turbines with quadruple exhaust, arranged as tandem-compound units as shown in the illustration. The final appearance will be rather different from many of the sets now installed as the steam from the medium-pressure cylinder is led to the two low-pressure cylinders by ducts that run along the side of set, instead of over the top. The low-pressure cylinder is arranged in two double flow casings, each exhausting into one of the two condensers that form the twin condensing unit. Solid couplings are fitted between cylinders and each shaft is mounted in two main bearings to give ease of assembly and maintenance. Basically the units resemble the 200 MW sets made by the same firm for the High Marnham station.

The first six stages of the high-pressure cylinder are contained in a double casing with the expanded steam returned between the walls to pass over the remaining stages. These features together enable the pressure differences and operating temperatures in the metal to be reduced, compared with those encountered in single-casing design. Ferritic materials can therefore be used. Castings have been employed for the steam chests and cylinder casings in preference to forgings as they provide a more uniform thickness of material without so much machining.

A similar partial double casing is used for the medium-pressure cylinder. It may be noted that the last blade of the low-pressure cylinder is believed to be the largest in the world on a 3000 r.p.m. turbine, having a length of 36 in. and running on a mean diameter of 100 in. The



Longitudinal section through 275 MW steam turbine being built by the English Electric Company.

Special Article

SATELLITE AND MISSILE GUIDANCE

We give below a summary of a lecture on "The Guidance and Control of Long Range Vehicles," given recently to the British Interplanetary Society in London by Mr. G. A. Whitfield, professor of aircraft electrical engineering at the College of Aeronautics, Cranfield, and previously concerned with guidance and control problems at the Royal Aircraft Establishment, Farnborough.

To put a ballistic missile on the right course at the end of turning off the rocket engines, the guidance has to be accomplished while the engines are still firing, so that side thrust can be obtained by tilting the motors. At the cut-off of the propellents, the vehicle must possess the correct combination of speed and angles of elevation and azimuth to enable it to reach its target. To achieve this, a continuous computation must be made, either in the vehicle or on the ground at the launching point at the end of a radio link. There is always a value of the elevation angle that requires the minimum launching velocity for reaching a given target, which lies between the extremes of shooting straight upwards and allowing the earth to rotate under the missile before it returns and strikes the target, and of a very flat trajectory. An advantage of operating at the minimum-velocity elevation is that the dependence of aiming error on elevation angle is then least. For the errors which may be tolerable in the performance of ballistic missiles, say 2 miles in a range of 2000 miles, the velocity at cut-off has to be controlled to less than 7 ft per sec in about 12000 ft per sec and the azimuth angle to less than 0·1°, while keeping the elevation angle at its nominal value.

Radar and Doppler methods together can give excellent accuracy in locating the vehicle in range and in estimating its radial velocity, and the lateral discrimination would probably be adequate, but such accuracy depends on a full knowledge of the prevailing propagation characteristics of the atmosphere between the vehicle and the radar set. There is a lack of knowledge of the velocity of electromagnetic radiation in the high atmosphere, especially in the ionised regions, and refraction may occur. These effects give errors in the observed range and bearing of the vehicle. Radar systems do allow a lot of computing to be done on the ground, but it is still necessary to have some equipment in the missile to determine its attitude.

The alternative to radar/Doppler is to use an inertial navigation system, comprising a platform in the vehicle, stabilised by having three gyroscopes mounted on it which sense any tilt of the platform and operate servo mechanisms to correct the tilt; on this platform are mounted three mutually perpendicular accelerometers which, with integration of their outputs, give a continuous indication of velocity and position relative to the launching point. While such a system is simple in concept, the practical difficulties are enormous; any rotation of the stabilised platform introduces an apparent cross-talk between the accelerometers, and it is necessary to use gyroscopes which drift no more than 0·2° per hour, as compared with about 30° per hour for normal aircraft gyros. Similarly, the zero errors and hysteresis of the accelerometers have to be kept at extremely low levels.

The systems discussed above are based on the use of liquid-propellent rocket engines, where it is possible to cut off the propellent flows to achieve a particular velocity. In the case of solid propellent motors, where exactly-timed cut-off of thrust is much more difficult, it is generally necessary to allow the motor to burn out in its own good time, and the control system has to operate in a rather different way. The climb angle is continuously adjusted during burning, so that velocity and angle are always matched, right up to the end of burning.

Turning to the placing of satellite vehicles in orbits: since quite large variations between apogee and perigee distances can be tolerated, the accuracy required in the navigation system is very much less than that needed for ballistic missiles. For most purposes, a suitable orbit can be achieved if three quantities are matched at the end of launch: the height, the elevation angle (nearly horizontal), and the orbital speed. For 100 miles difference between apogee and perigee, a 500 mile/h error in final launching velocity, or a 1° angle in deviation, can be tolerated. However, the satellite system is more complicated than the ballistic missile, since, to achieve a vehicle with an efficient use of its propellent load, it is necessary to allow the later stages to coast into orbit after a fairly early burn-out of the first stage. This is likely to result in great uncertainty about the attitude of the vehicle when it has finished coasting, and some provision must be made for controlling the attitude so that the later stages will go where they should.

In the Vanguard vehicle, attitude control is to be achieved by retaining the guidance equipment in the second stage and using jets of helium to tilt the vehicle, but the successful Jupiter "C"/Explorer I satellite uses a rather more ingenious method. The second, third and fourth stages form a cluster of solid propellent rockets about the satellite, and this barrel-like structure is mounted on the front of the Redstone first stage in bearings which allow it to rotate axially. Before launch, the cluster is spun up to about 750 rev/min and it then acts as a gyroscope to stabilise the axis of the whole vehicle system. At the end of first-stage burning, the axis of the vehicle will not lie exactly parallel to the trajectory at that instant, due to errors in the alignment of the first-stage thrust vector, but the error will be small enough (less than say ½°) to permit an orbit being achieved. The whole assembly coasts up and past the zenith of a ballistic trajectory: at a computed instant, the second stage is fired, the downward component of velocity in the coasting trajectory being then cancelled by the upward components due to the velocity increments of the subsequent stages, which are tilted upwards in the attitude at which cut-off occurred, and the satellite finally achieves a near-circular orbit.

Continuing Turbo-Alternators Reach 275 MW

overall length of the set including the alternator and exciter is about 140 ft.

The alternator employs the direct hydrogen cooling system first used in their 120 MW sets for Willington A. For the new sets the hydrogen will be pumped at a pressure of 45 lb per sq. in. by means of a high-speed gear-driven blower. Although the drive for this will probably be taken from the main shaft of the turbine, the possibility of a separate drive from an electric motor or even from a separate turbine has not been entirely excluded; however a separate drive would involve some additional safety devices to guard against blower failure. As a result of using this higher gas pressure, it has been possible to obtain the rated output of the machine—275 MW or 323·5 MVA at 16 kV—with only a slight increase in frame size over the 200 MW machines.

Steam conditions at the turbine inlet will be 2300 lb per sq. in. and 1050° F. There will be one stage of reheat to 1050° F and 565 lb per sq. in. The condensers will be of the shell type having a total area of 165000 sq. ft and working at a pressure of 1 in. of mercury absolute. They will require 110000 gal/min of cooling water at 52° F. One half of each condenser can be isolated for tube cleaning with the set on load. For heating the feed water there are seven bled steam stages comprising three surface type low-pressure heaters followed by a high level storage de-aerator of the direct contact type, and by three high-pressure heaters also of the surface type. The last high-pressure heater will be split into two units arranged in parallel. The feed system employs dual pumping, the three high-pressure heaters being interposed between the booster feed pump and the main boiler pump. The latter will probably be driven from the alternator shaft through a variable-speed fluid coupling. The booster and stand-by pumps will be electrically driven.

Steam for the turbines will be provided by two boilers, one for each set, following the unit plan of the C.E.G.B., to be built by Yarrow and Company Limited, Glasgow. The rated evaporating capacity of each is 1,900,000 lb of steam per hour at 2400 lb per sq. in. and 1055° F. They will be of the controlled circulation type with twin furnaces burning pulverised coal. Supplies will probably be drawn from the Yorkshire area, and at full load the consumption of each boiler will be between 115 and 135 tons per hour. Low grade coal will be used but the range of ash content that can be handled has not been released. Superheating will be carried out in both furnaces but one will be used for the reheat only. Each boiler will be fed from six Yarrow mills with an extra for standby; four can handle the full load. The system of ash disposal and figures for the thermal efficiency have not yet been made known.

Each boiler with its pulverising plant, air-heaters, fans, electrostatic precipitators, and flues will occupy a ground area of 150 ft by 375 ft. The height will be about 165 ft.

MORE ABOUT ROCKET FUELS

Some additional information on the fuel used in the Jupiter "C" rocket that launched the Explorer I satellite on January 10 has been submitted by the author of the article on "Boron-Containing Rocket Propellents" published in our February 28 issue. It appears that the high-energy fuel Hydyne is not, as was first supposed, a boron-containing fuel but in fact is based on hydrazine. According to *Aviation Week* (February 10), Hydyne was developed by the Rocketdyne division of North American Aviation Incorporated, the makers of the first stage rocket engine, and is "a unique blending of two commercially available chemicals that never before had been used at the high thrust levels of rocket engines." Quantity production of Hydyne has been entrusted to commercial chemical makers.

The fuel has physical properties very similar to those of alcohol; and the alcohol normally used as fuel in the Jupiter "C" may be replaced by Hydyne without any change in "engine hardware or missile tankage," giving a 12 per cent. increase in burning time and all-burnt velocity, which indicates that (as demonstrated for pentaborane fuel) the exhaust velocity will be increased to about 9000 ft per sec, while the mass flow rate will be reduced, giving only a small increase in thrust.

Atomic Review

Fluid State

THOUGH reactor development is solidifying along certain well-defined axes of advance, there remain areas in which the situation is still fluid. Last week, for example, we referred to exploratory work in progress in Australia and the United States on the liquid-metal-fuel reactor, and to certain other reactor systems under consideration. A more detailed account of American studies in the field of liquid-metal fuels is published in one of the following notes. The article begins with a summary of design data for the 500 MW nuclear power station under construction at Hinkley Point, and continues with notes on liquid-fuel reactor systems. Finally, there is the usual miscellany of general notes and news items.

Hinkley Point Station

The 500 MW nuclear power station under construction at Hinkley Point is being built for the Central Electricity Generating Board by the English Electric—Babcock and Wilcox—Taylor Woodrow Atomic Power Group, and when completed will be the largest in the world. A second 500 MW station is planned for Trawsfynydd in North Wales. The Hinkley Point station, which has been designed by the group in conjunction with the C.E.G.B., will have two gas-cooled reactors housed in separate buildings. A cut-away view of one reactor building is shown in Fig. 1, and design data for the station are listed below. Previous reference to the station was made in Atomic Review 20 and 27 Sep. '57. Details of the nuclear power stations already under construction at Bradwell, Berkeley and Hunterston have been published in Atomic Review, 21 and 28 Dec.' 56, 1, 8, 15 and 22 Feb. and May 31 '57.

Reactors.—Two gas-cooled graphite-moderated type, each contained in a 67 ft (20·4 m) diameter spherical pressure vessel of steel 3 in. (76·2 mm) thick. Weight of each reactor with pressure vessel, 5,500 tons.

Fuel.—Natural uranium in magnesium-alloy cans. Refuelling from top of reactor while reactor is pressurised and on full power.

Boilers.—Six per reactor, Babcock dual-pressure type, each 90 ft (27·4 m) high, 21 ft 6 in. (6·6 m) diameter, weight 1,350 tons. Total evaporation, 5·5 million lb (2·5 million kg) of steam per hour.

Gas Circulators.—Six per reactor, electrically driven, axial-flow type.

Main Electrical Generation.—Six 3,000 r.p.m. English Electric, hydrogen-cooled 3-cylinder turbo-alternators, each 93·5 MW at 13·8 kV, 0·85 power factor.

Auxiliary Generation.—Three 33 MW variable-speed turbo-alternators; for supply to gas circulators and other duties.

Transmission.—Through switching and transformer station into national Supergrid system at 275 kV.

Cooling Water.—35 million gallons of sea water per hour, circulated by six centrifugal pumps.

Civil Engineering.—Includes construction of two 180 ft (54·9 m) high reactor buildings, the 740 ft (225·6 m) long turbine-hall and all other buildings, reactor biological shields of high-density concrete, 7 ft (2·13 m) thick, 3,000 ft (914·4 m) long sea-wall, circulating-water intake with 2,200 ft (670·6 m) long tunnels under the sea beds; dock, wharf, approach roads, and other items. Involves 750,000 cu. yd. (573·750 cu. m) of excavation and placing of 300,000 cu. yd. (229·500 cu. m) of concrete.

Liquid-Metal-Fuel Reactor

Reference to the Liquid-Metal-Fuel Reactor Experiment (LMFRE), a design for which has been prepared by the American Babcock and Wilcox Company, was made in Atomic Review last week. Details of the study have been published in the company's papers BAW-1012 and BAW-1004. A summary of the conclusions appears in *Power Reactor Technology—A Summary of Recent Developments*, prepared for the Atomic Energy Commission by Dr. Walter H. Zinn and associates of the General Nuclear Engineering Corporation, Dunedin, Florida. The substance of their remarks are given below. The first Babcock and Wilcox paper mentioned provides an economic comparison of large-scale (200 MW electrical) liquid-metal-fuel reactors operating as uranium 235 burners and uranium 233 breeders. The second paper refers to recent progress with a low-power pilot plant.

LMFR Designs Compared

In the liquid-fuel reactor concept a solution of uranium 235 or uranium 233 in liquid bismuth is circulated through a reactor core vessel containing graphite moderator, where the solution is critical and generates fission heat, and through an external heat exchanger where the heat is removed for power production. Many of the design and operating features of such a reactor result from the limited solubility of uranium in bismuth. In the study covered by Babcock and Wilcox, paper BAW-1012, it is assumed that the maximum usable concentration is 1,500 parts per million (ppm) of uranium in the bismuth.

The mode of operation of the burner reactor is visualised as follows. The reactor is started with that concentration of uranium 235 which will provide the necessary reactivity for operation. As the operation proceeds and the concentration of fission products and higher uranium isotopes builds up, more uranium 235 is added as necessary to maintain reactivity until the maximum feasible concentration, as limited by solubility, is reached. The bismuth is then cleaned up by removing the fission products and uranium, which are shipped for separation to a government or privately-owned facility. Evidently the use of a large core tank with a large bismuth capacity will favour a long operating period before cleaning of the bismuth is necessary. It is stated that a large core size (8 ft diameter) was selected for this reason. The power density in the core, for 200 MW electrical output, would be approximately 70 kW per litre. It is estimated that such a reactor will have a life of between six and twelve years before cleaning of the bismuth is necessary. The uncertainty in lifetime results from uncertainties in fission-product build-up. The average uranium concentration in the six year reactor would be 1,055 ppm; this concentration is equivalent to an average inventory of 735 kg of uranium 235. The twelve-year reactor would have an average concentration of 768 ppm, and an average inventory of 536 kg. The chemical plant for the burner reactor is expected to consist of a degassing system (for removal of gaseous fission products), a system for addition of fuel and at least partial removal of fuel, and the bismuth cleaning system.

The core of the breeder reactor is similar to that of the burner, except that the fuel is uranium 233. The core is conceived to be contained in a graphite-walled vessel, which is surrounded by a fluid blanket containing thorium. In addition to the chemical plant components of the burner reactor, the breeder includes systems for fission-product removal from the core and for blanket processing. These processes are expected to be fluoride volatility or fused-salt contacting processes. The converted uranium 233 which is removed from the blanket is fed into the core as required to maintain reactivity. The breeding ratio is estimated to be 1·0.

Because of the removal of fission products and because of the lower production of non-fissile uranium isotopes when uranium 233 is used as fuel, the breeder reactor can operate for a long time before the solubility limit is reached. The lifetime before bismuth cleaning is necessary is estimated to be 100 years; however, it was assumed in the economic analysis that cleaning takes place at the end of 30 years of operation. The average uranium concentration in the reactor over the 30 year period is 1,200 ppm, corresponding to an average inventory of 765 kg of uranium 235.

It is estimated that, exclusive of costs for reactor and turbo-generator operation and maintenance, the six-year burner will make power at a cost of 6·86 mills (0·00686 dols.) per kilowatt-hour, the twelve-year burner will make power at 6·69 mills per kWh, and the breeder will make power at 5·94 mills per kWh. The fuel burn-up cost is 1·985 mills per kWh for the two burner reactors and 0·003 mills per kWh (the cost of thorium make-up) for the breeder reactor. If the total fuel cost is taken to be the sum of the burn-up cost plus the inventory charge plus the cost of maintenance and operation of the chemical plant plus the cost of bismuth clean-up plus a capitalisation charge on the cost of the chemical plant, then the estimated costs are 2·84, 2·67, and 1·58 mills per kWh for the six-year burner, the twelve-year burner, and the breeder respectively. These figures are derived on the assumption of a 13·5 per cent. per year capitalisation charge on the cost of the chemical plant which is estimated in the paper. The total installed capital cost for the plants (including the chemical plants) is estimated as 194 dols. per kilowatt for the burner plant and 215 dols. per kilowatt for the breeder.

Thoria-Bismuth Slurries Studied by G.E.C.

The study of reactors employing liquid-metal slurries has been pursued at Harwell for some years and also in collaboration with the Australian Atomic Energy Commission. A new research project sponsored by the Atomic Energy Research Establishment has been undertaken by the General Electric Company, and is discussed in the latest issue of the *G.E.C. Journal*. The project is concerned with the properties of slurries, or suspensions of thorium and uranium compounds in liquid metals for use in breeder reactors. In a reactor of this kind a convenient form of breeding blanket would be a slurry of a thorium compound in liquid bismuth, and for this to be stable over the range of operating temperatures, the thorium compound must have approximately the same density as the liquid metal, it must be substantially insoluble in the liquid and it must also be wetted by the liquid. Thoria in liquid bismuth satisfies the first two conditions, and recent work at the Wembley laboratories of G.E.C. has shown that wetting of the thoria particles can be achieved by suitable processing. Work is continuing on a more detailed study of the behaviour of such a slurry under conditions simulating those likely to be met in a reactor.

Notes and News

British Participation at Geneva

Conference.—In July last year it was announced that the British Government had accepted an invitation from the Secretary-General of the United Nations to participate in a second International Conference on the Peaceful Uses of Atomic Energy, from 1 to 13 September, 1958. The provisional agenda agreed by the seven-nation Advisory Committee covers all aspects of the peaceful applications of atomic energy. The president of the conference is to be Professor F. Perrin of the Commissariat a l'Energie Atomique de France and the secretary-general, Dr. S. Eklund of Sweden. Arrangements for United Kingdom participation are being organised by an executive committee (chairman, Sir John Cockcroft; secretary, Mr. B. W. Mott) and a papers committee (chairman, Dr. B. F. J. Schonland; secretary, Dr. T. A. Hall), with a secretariat operating from the Atomic Energy Research Establishment, Harwell. The members of the committees have been drawn from the U.K. Atomic Energy Authority,

the electricity boards, industry, the Medical Research Council, universities, and other organisations. The papers committee has considered the suitability of a large number of suggested papers and has selected about 200 for submission to the United Nations. This represents about 10 per cent. of the total number expected from all participating countries and is approximately the same percentage as in the previous conference in 1955, when the total number was about 1,000. Included in the 200 proposed United Kingdom papers are eight which deal with fundamental work in the thermonuclear energy field. The approximate distribution of papers is 60 per cent from the U.K. Atomic Energy Authority, 22 per cent from industry and 18 per cent from M.R.C., hospitals, universities and others. A provisional agenda for the conference was published in Atomic Review, 3 Jan. '58.

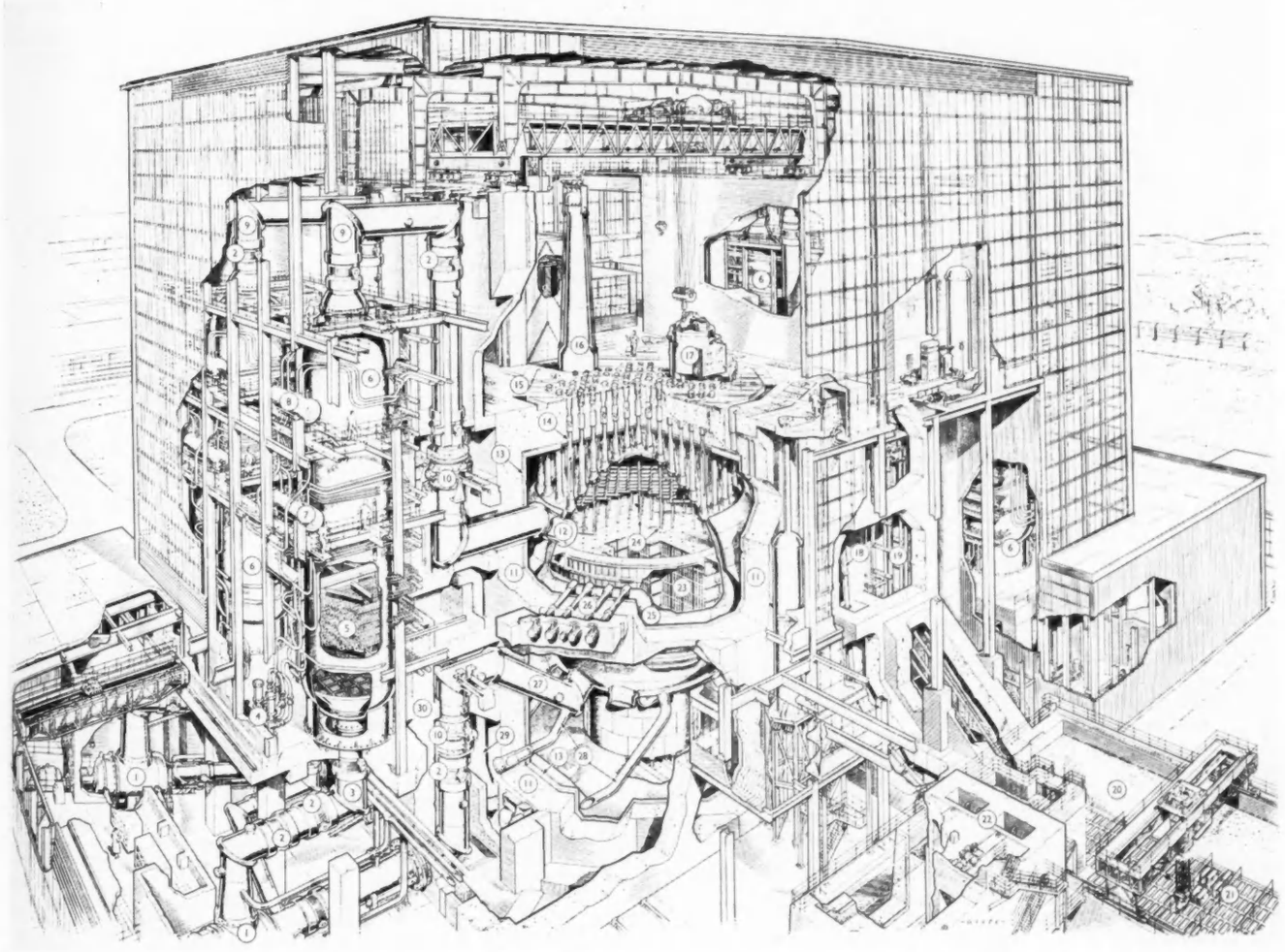
Exhibitions.—As in 1955, two atomic energy exhibitions will be held in Geneva during the Conference. The first of these will be a scientific exhibition under the auspices of the United Nations, at the Palais des Nations. A United Kingdom exhibit, 5,000 sq ft in extent, is being arranged by the Atomic Energy Authority. A prominent feature of the British display will be a model of the thermonuclear research assembly, Zeta. The other, which will be commercial, is the International Exhibition on the Peaceful Uses of Atomic Energy, at the Palais des Expositions. The British Section at this latter exhibition is being organised by the Nuclear Energy Trade Associations' Conference, which represents all major British firms concerned with atomic energy. More than fifty British firms will be exhibiting in this section, which will alone cover more than 30,000 sq ft, and will include an exhibit of 3,500 sq ft by the Atomic Energy Authority.

Delegation.—The United Kingdom delegation is expected to consist of five delegates, about 250 advisers and about 250 observers, the advisers being drawn primarily from among the authors of papers. The leader of the United Kingdom delegation will be Sir John Cockcroft, Member for Scientific Research of the United Kingdom Atomic Energy Authority. The other four delegates are expected to be a second representative of the Authority and representatives of the Royal Society, British industry, and the Medical Research Council. The demand for observer passes has already been very high and to help the organisers to arrange a fair distribution, the organisers request that all people interested in attending the Conference as observers should apply for passes as soon as possible, and in any case not later than 19 April, 1958. Representatives from industrial firms who are working in the atomic energy field should apply to Mr. M. H. L. Whitehouse, Nuclear Energy Trade Associations' Conference, 32 Victoria Street, London, S.W.1, and all others to Mr. J. C. Walker, United Kingdom Atomic Energy Authority, 11 Charles II Street, London, S.W.1. The United Kingdom representatives on the United Nations scientific secretariat for the conference will be Mr. W. B. Woollen (Atomic Energy Research Establishment, Harwell), Mr. T. E. F. Carr (Medical Research Council) and Mr. F. Hudswell (A.E.R.E., Harwell).

Structural Insulation in Zeta

Zeta is in principle a large transformer in which the gas to be heated forms a single-turn short-circuited secondary winding. The main primary winding and magnetic core of the apparatus requires support and clamping at numerous points where high magnetic flux densities occur during pulsing, with heavy mechanical loadings. For this reason the main contractors, the Metropolitan-Vickers Electrical Company, employed considerable quantities of Permali in the construction of the apparatus. This material is a resin-impregnated, densified wood laminate chiefly used for high voltage electrical insulation.

The main magnetic core system consists of discs wound from transformer-iron strip mounted



Cut-away view of one reactor building for the 500 MW nuclear power station under construction at Hinkley Point. The station, which is being built by the English Electric—Babcock and Wilcox—Taylor Woodrow Atomic Power Group for the Central Electricity Generating Board, will when completed be the largest nuclear power station in the world.

1. Coolant-gas circulating blowers.
2. Hinged expansion bellows.
3. Coolant-gas outlet from steam-raising unit.
4. Steam-raising unit circulating pumps.
5. Stud-tube elements.
6. Steam-raising units (six per reactor).
7. Low-pressure steam drum.
8. High-pressure steam drum.
9. Coolant-gas inlet to steam-raising unit.
10. Coolant-gas isolating valves.
11. Main biological shield.
12. Coolant-gas outlet from reactor.
13. Thermal shield.
14. Charge tubes.
15. Charge floor.
16. Hole-preparation machine.
17. Charge and discharge machine.
18. Emergency discharge chute.
19. Spent fuel-element skip hoist.
20. Cooling pond.
21. Storage skips and grid.
22. Skip loading bays.
23. Graphite-moderator core.
24. Control rod.
25. Reactor pressure vessel.
26. Can-failure detection standpipes.
27. Coolant-gas inlet to reactor.
28. Debris-removal ducts.
29. Shield cooling-air ducting.
30. Secondary biological shield.

Continuing Atomic Review

around the two straight portions of the torus. These core assemblies rest in cradles formed by densified laminated wood beams. They are also fitted with stepped supports of the same material which carry the smaller discs forming the end of the core. The total weight supported by each cradle is over 70 tons. The core assemblies are retained in vertical alignment by means of end clamp rings of densified laminated wood some 10 ft in diameter. These rings are supported from main steel end frames by means of Permali bracing arms, which are fitted with adjusting and jacking screws, enabling the position of the core assemblies to be accurately adjusted and ensuring even support. The main primary winding of the transformer consists of insulated cables wound around the core, in the same way as on a ring-type transformer, and passing through the bores which they share with the torus. Where these cables pass across the end rings they are clamped in position by means of cleat assemblies of densified laminated wood, which is also used for studs, nuts and additional members in other parts of the structure.

In addition to this material, Permali Limited supplied the polyester resin glassfibre coil formers which support and locate the windings on the torus itself. These supply the stabilising field used to prevent " wriggling " of the hot gas column during operation. Each coil former consists of three segments connected by flanges to facilitate assembly in the restricted space available.

Homopolar Generator for Thermonuclear Work

Instead of condensers, a homopolar generator may be used as a power supply for a gas-discharge apparatus to be built at the Australian National University. Professor Marcus Oliphant, director of the Research School of Physical Sciences at the university, is reported to have said that attempts would be made to hold temperatures in the thermonuclear range for as long as half a second. So far, such temperatures have only been sustained for periods of a few thousandths of a second in Zeta. According to *The Times*, the homopolar generator at the Australian National University comprises four discs of mild steel, each weighing 19 tons, which rotate at speeds of 900 rev/min. between the poles of a magnet 12 ft in diameter. Peak currents of more than one million amperes are taken from the discs through jets of molten sodium or sodium-potassium alloy. When running at full speed the discs can store energy about 1000 times greater than is consumed during a single pulse in Zeta. Large pulses may thus be supplied to a gas-discharge apparatus connecting it to the generator through the liquid-metal jets.

Zeta Described

A 24 page illustrated book describing the thermonuclear assembly, Zeta, at Harwell has been published by the U.K.A.E.A., price 1*s.* 6*d.* *Facts About Zeta* can be obtained from H.M. Stationery Office.

Heisenberg Equation

The theory developed by Professor Werner Heisenberg in collaboration with Professor Wolfgang Pauli, and referred to in Atomic Review last week, appears to be primarily an attempt (in the light of the discovery that conservation of parity does not invariably apply) to reconcile all known nuclear particles in terms of a single equation. Thus from the equation it would be possible to deduce the properties not only of electrons, protons and neutrons but also of mesons, including those not yet detected experimentally. It is conceivable that this result might be of practical importance, since it would presumably be possible to ascertain whether or not a particle existed or could be created having the properties (long-lived, negative charge and roughly 200 times the mass of an electron) necessary to catalyse in a fruitful manner the cold fusion reaction observed at the Universities of California and Liverpool (see Atomic Review, 24 Jan. '58 and 11 Jan. '57).

Professor Heisenberg, speaking at the headquarters of the European Organisation for Nuclear Research (C.E.R.N.) last week, emphasised during a meeting of the division of theoretical studies that development of the new theory was due also to Professor Wolfgang Pauli, of Zurich. It was Professor Pauli who postulated the existence of the neutrinos, to explain certain discrepancies in the energy constitution of nuclei. The track of a neutrino has recently been observed. The proton synchrotron under construction at the headquarters of C.E.R.N., at Meyrin near Geneva, and due to begin operations in 1960, will be employed in experimental work to test the theory.

Though the equation seems mainly concerned with sub-atomic particles, it is reasonable to suppose (particularly in view of Professor Heisenberg's reported remarks when describing the work recently in Göttingen) that a unified field theory may emerge from it. Once the character of the ultimate constituents of matter and the forces that hold them together are fully understood, the nature of the physical universe, even on a macroscopic or cosmic scale, will be more readily intelligible.

International Insurance Conference

The second International Atomic Energy Insurance Conference, held recently in London and mentioned in Atomic Review last week, resulted in widespread agreement by insurance representatives from 15 European countries on an approach to the insurance of risks arising out of the use of atomic energy reactor installations. The conference, which lasted three days, was sponsored by the British Insurance (Atomic Energy) Committee. The committee, set up in 1956, represents British insurance companies and Lloyd's underwriters and is a means of marshalling the resources of the British insurance market to form a single insurance pool to provide the underwriting capacity required to cope with the many millions of pounds involved in covering atomic energy risks. In addition, it is a method of ensuring maximum co-operation between individual insurers and of facilitating the exchange of technical information between one insurance market and another. The guests of the committee at last week's conference consisted of 35 delegates representing the atomic insurance pools of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Sweden, Switzerland, Turkey. Further details may be obtained from Mr. R. T. D. Wilmot, Secretary, British Insurance Association, 59-67 Gresham Street, London, E.C.2.

It was decided that the material damage risks to be covered by a pool management agreement should be the insurance of damage to property belonging to the policyholder, comprising damage to atomic installations, provided that insurance includes contamination by radioactivity and damage to any other property of the same policyholder due to contamination by radioactivity emanating from his atomic installation. It was also agreed that third party liability for damage to property and loss of life and injury to persons arising out of the use of atomic installations should be pooled. It was unanimously agreed as a general principle that no atomic energy insurance pool would cover material damage to atomic reactors for nuclear risks only—in other words, each reactor must be covered comprehensively. A similar understanding was reached as regards the insurance of third party liabilities.

Three of the items on the agenda are to be the subject of deliberations by a special committee. They are: (1) hazards, evaluations and surveys; (2) bases of premium rating; and (3) policy cover to be offered. A committee to consider these questions is to be convened in Paris in the second half of April.

The conference endorsed the approach to the problem of the British insurance market. This is contained in a recommendation in the British Insurance Atomic Energy Committee's detailed report on atomic energy risks and their insurance published in June, 1957. It says: " The extent to which cover could be provided against loss of profits and consequential loss, following the shut-down of a reactor after an incident, would be a matter of market capacity. If the capacity had already been exhausted in the case of a large reactor installation, cover in this respect could not be provided. Where, however, the capacity had not been exhausted, insurers could consider the possibility of providing cover." All the countries attending the conference endorsed the principle that a single insurance policy be effected by the reactor owner/operator, who should accept all responsibility for radiation liabilities for contractors and suppliers of parts, as well as for himself, and the owner/operator would undertake to indemnify the contractors and suppliers of the parts from any legal liability that they might have for radiation risks. This approach to the problem of channelling legal liability is to ensure that any claim from a third party should be made simply and solely against the reactor owner or operator. In the United Kingdom, the Government has accepted that the problem should be tackled on these lines, and it proposes that the owner of a reactor shall be under an absolute liability at law and shall be required to insure to a sum of £5 million or else show that he has liquid assets available to that amount. In a number of countries, it will not be possible to channel liability to the reactor owner or operator at the outset. Where this situation pertains, the conference decided that contractors working on the construction of atomic installations and suppliers of parts and materials should be offered individual policies to safeguard them against their legal liability, provided that the amount of cover required is within reasonable limits.

The conference unanimously resolved that special legislation must apply to legal liabilities arising from the use of reactors. This would involve the harmonisation as far as possible of existing law in the various countries. Legislation would deal with such matters as the channelling of liabilities, limits of liability and exceptions from absolute liability (i.e., act of God) and the periods within which claims against the operator must be notified. It was decided that these and related matters should continue to be dealt with by the Organisation for European Economic Co-operation and the Comite Europeen des Assurances.

Quarterly Review of Reactor Technology

A technical progress review, *Power Reactor Technology*, is to be issued quarterly by the United States Atomic Energy Commission, and is available on subscription for 2 dols. per year in the United States and 2·50 dols. abroad, or at 55 cents per copy from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Prepared for the U.S.A.E.C. by General Nuclear Engineering Corporation, Dunedin, Florida, it is designed to assist interested organisations in the task of keeping abreast of new results in reactor technology for civilian application. Selected phases of research and development are discussed in which there have been significant advances or heightened interest during the quarter. It is not intended as a comprehensive abstract. The principal editor is Dr. W. H. Zinn.

James Forrest Lecture

" Further Developments in Nuclear Power " will be the subject of the James Forrest Lecture, to be delivered by Sir John Cockcroft at the Institution of Civil Engineers on 18 March at 5.30 p.m.

Radioactive Contamination of Sewage: Course

The Department of Civil and Mechanical Engineering, University College London, is planning to conduct an evening course of lectures on radioactive contamination of water and sewage, for practising civil engineers. It follows to some extent the recommendation of the Committee appointed to examine the Organisation for Control of Health and Safety in the U.K.A.E.A. (H.M.S.O. Cmd. 342, January, 1958) who suggested *inter alia* (para. 98) that sanitary and water engineers will require knowledge to understand radiological hazards and methods of checking whether any contamination or exposure has occurred. The course, lasting from April 28 to May 15, will be held in the Mechanical Lecture Room, Faculty of Engineering, University College, on Mondays and Thursdays (5 p.m. to 7 p.m.), and is intended for civil engineers with no previous knowledge of the subject. There will be no charge for the course, but admission will be by ticket only, as accommodation is limited. Applications for tickets should be made to Professor H. John Collins, Department of Civil and Municipal Engineering, University College, Gower-street, London, W.C.1, to whom all inquiries should be addressed.

Companies in the News

World Strategy

The annual report of the Caterpillar Tractor Company is a fascinating commentary on the fluctuations in business activity during the past year and on future prospects. The company are extending their manufacturing facilities in countries outside the United States, and they have 264 dealers "operating over 800 separate places of business strategically located throughout the free world." Their comments are therefore valid for the world as a whole, and based on very close contact with market trends.

The year 1957 began with a boom when Caterpillar machines were being rationed to dealers. Sales during the first half were well above the comparable period of 1956. In the third quarter they began to fall and fell sharply in the fourth quarter. As a result the year as a whole was no better than 1956. The reasons the report gives for the change in the course of business included "lower than anticipated expenditures for the earthmoving phases of highway construction," decline in housing and other private construction, restricted credit and weaknesses in other markets such as logging and mining. Changes such as these, comments the report, are to be expected from time to time: "Business and Governmental actions may operate to minimise fluctuations in the business cycle, but they cannot eliminate them. In such circumstances, the job of business management includes adjustment and adaptation to the changing conditions."

This realistic attitude is typical of a company who have had to live through several recessions and yet have expanded steadily over a long period. Their confidence in the future remains undiminished. All of the markets they serve are described as "capable of great expansion." The rapid increase in world population—"multiplying at the most rapid rate in history"—the fact that all over the world "greater numbers of people are reaching for a higher standard of living and coming to a recognition that they can have it" are the basic factors in the company's confident outlook. The United States Federal Highway Programme is quoted as a decisive factor in demand during the next two years, and in general there is an expectation that an upturn in business will not be long delayed. The expenditure of £26·3 million on plant additions in 1957 is evidence enough that for Caterpillar the way ahead is filled with opportunities.

Better than Most

The preliminary results of English Electric, published last week, have taken investors by surprise and most pleasantly so. Group trading profits are up by 7½ per cent to £9·69 million. Since the shock of the interim results of G.E.C., who forecast "a marked decline" for the year as a whole, and the results of A.E.I., who showed a fall of 7½ per cent in trading profits over the first half of their financial year (the same as English Electric, to end-December), few could have expected this fine performance.

English Electric are structurally very different from the other major electrical engineering groups, in so far as they are involved in a major way in aircraft and directly in locomotives. The very good orders for their P.1 fighter received since it became a production model must have provided most useful and profitable turnover throughout 1957. Locomotive manufacture did not prove at all profitable and their subsidiary Vulcan Foundry turned a gross profit of £139,000 to a loss of £286,000. The Marconi group of subsidiaries on the other hand, manufacturing electrical instruments and telecommunication equipment, probably had a very good year. The sharp recovery of consumer demand for electrical household appliances which took place in the early summer must also have played a part in the profitability of the English Electric group, and will doubtless affect the final results of the other large electrical engineering groups.

Steel on the Turn?

The improvement in the demand for rolled steel products which began with the recovery of production last spring is being well maintained. In his annual statement to the shareholders of the Whitehead Iron and Steel Company Limited, their chairman, Mr. G. H. Latham, commented that the trend of demand "continues to be equally satisfactory." Whitehead's make bar, strip and wire and are highly dependent on the motor industry to keep their works fully employed.

In the United States there have been signs that the very severe recession in the steel industry may be coming to an end. Several large mills have noted a slight improvement in the volume of incoming orders and the national metal-working magazine, *Iron Age*, reports that it has received further confirmation that the bottom of the recession has been reached. Some steel buyers "are taking another look at their policy of inventory cut-backs" and if they decide to buy—such decisions are normally made simultaneously by large numbers of small buyers as well as big ones—the flow should be restored to something like normal in the pipeline. One of the major companies quoted by *Iron Age*, Jones and Laughlin (the fourth largest in the United States), reported that steel users are rapidly eating into their stocks and that these have been diminished at the rate of a million tons a month for the past seven months. It is likely, therefore, that demand will pick up to replenish users' supplies.

Tinkering with Tin

The chairman of Petaling Tin Limited, Mr. J. T. Chappel, told shareholders that the company's immediate prospects, like the rest of the Malayan tin industry, depend on the rate of industrial activity, "particularly in the United States, and on the extent to which Russia will continue to release supplies of the metal on to the market." On the longer term outlook, however, Mr. Chappel was confident.

The International Tin Council met last week to review the working of the restrictive measures introduced two months ago to check the fall in world prices. The present trend suggests that the measures are being reasonably successful, although there are other factors at play and it may be too early to judge. One of these is that the pipeline has not yet been cleared; for example, spot supplies in London are ample. Another is that the level of shipments from the Council countries have been higher than anticipated. It obviously must take a few weeks before restrictive measures can exert their full influence. The most important measure taken by the Council was a cut of 40 per cent in the exports from the six major tin producing countries for the three and a half months ending March 31 and for the following quarter. Among the signs that these restrictions are beginning to work was a rise in prices last week and a little firmer tone in the market. The expected recovery in prices may therefore occur soon.

The most depressing influence on the market remains the relative absence of United States buying and the continued uncertainties about the outlook for the United States economy. Elsewhere, the demand has either been maintained or fallen only slightly, but even had it risen the United States influence would have been dominant. The lesson seems to be that already noted by Caterpillar and discussed in another note on this page, namely that whatever measures are taken by industry or by Government it is unrealistic to expect trade recessions to be eradicated quickly and completely. The influence of innumerable buyers the world over, who are swayed primarily by their expectations of further falls in price, is too powerful and much too widespread.

Standard in the Fields of France

The modernisation of farming techniques on the Continent has made much progress in the last decade, notably in France and Germany. A consequence of this has been the excellent sales record of British tractors in western European markets. British manufacturers have thus become increasingly optimistic about their products there if the Free Trade Area becomes established.

The Standard Motor Company is already well placed. Its connections in France enable it to get off to a good start in the European Economic Community (the European Common Market) without having to wait for the F.T.A. The latest stage in the enlargement of facilities in France by a £2 million expansion programme was completed last week. A new factory was opened at Beauvais to be run by Standard-Hotchkiss. It is on a 50 acre site and can be expanded to eight times its present size. Standard has a 50 per cent holding in Société Standard-Hotchkiss, the remainder being shared by Massey-Harris-Ferguson and the French Hotchkiss company. When the new factory gets into its stride it is expected that, together with the company's other factory at St. Denis, a rate of output of 150 tractors a day will be achieved.

No decision has yet been taken as to whether Standard will make cars in France. Some thought has been given to the possibility of making the Triumph TR3 sports car but this has gone no further than a costing exercise.

Dealing in Cars

The magnificent recovery of motor vehicle production last spring and summer has led to excellent results and confident expectations from the leading distributors in the industry. H. and J. Quick, main Ford dealers, announce, through their chairman, Mr. T. W. Quick, that they are continuing to expand "in anticipation of the rapid growth of the motor industry in the next few years." Their plans include extensions to premises and the development of workshops to provide additional service facilities. Henlys Limited do not lag far behind H. and J. Quick in their optimistic outlook. Their chairman, Mr. H. G. Henly, told shareholders that his company "continue to be on the alert for acquiring existing businesses."

A policy of expansion is also being implemented by E. J. Baker and Company (Dorking), the Vauxhall and Bedford main dealers. Mr. E. J. Baker, their chairman, reported the acquisition of a new branch. This way of expanding activities is likely to become popular with the larger distributors. Mr. Baker attributes most of his company's difficulties during the first half of their financial year (ended at September 30) to the Suez crisis and the petrol rationing that followed. Neither in this case, nor in that of the other two firms mentioned, is credit restriction mentioned as a major factor in influencing demand for cars. The effect has apparently been greater on the sale of commercial vehicles than on that of cars, a reflection perhaps of the considerable emphasis most large and medium sized firms are now placing on sales, with consequent increased purchases of cars for their representatives, whereas small businesses—relying overwhelmingly on hire purchase facilities ot finance their buying of vans and trucks—have drawn in their horns to a far greater extent.

Despite the many optimistic statements contained in these reports, there is a general realisation in the trade that the present boom is unlikely to go on unabated for another six months.

In Parliament

AUTOMATIC TRAIN CONTROL

Mr. Philip Goodhart, the Conservative member for Beckenham, took advantage of his success in the ballot to introduce an adjournment debate in the House of Commons last Friday on the subject of automatic train control. He agreed that train accidents, even minor ones, made headlines because they were rare events but pointed out that many of his constituents had been killed in the Lewisham railway disaster on December 4.

On the whole, the story of safety on the railways was a good one but the chapter relating to automatic train control made curious reading. There were several systems and, generally speaking, they consisted of a device which warned the driver of a train by buzzer, siren or bell when he was passing a signal showing that there was danger ahead. The majority of these systems could bring a train to a halt automatically if the driver ignored the warning.

Automatic train control was developed by the Great Western Railway early this century with tremendous success and, in 1920, a high-powered committee, after investigating A.T.C., recommended its general adoption on all British railway lines. Five years later, another committee recommended the general adoption of A.T.C. and specifically praised the Great Western Railway's system.

From 1920 onwards, all Ministers of Transport had made obeisance to the general idea of automatic train control, but without very much happening. Before the Second World War there had been one or two experiments but it was true to say that, in general, the Great Western Railway had A.T.C. and the other British railways did not. He believed that about 65 per cent of the Great Western lines were protected by A.T.C. Some senior officials of the G.W.R. had felt that the refusal to install their system throughout the country was largely based on jealousy, because that system was known as the Great Western system.

EFFECT OF NATIONALISATION

With nationalisation, a great scheme was put forward, whereby British Railways would spend some £6 million on the quick installation of automatic train control throughout the country. Sir Alan Mount, chief inspecting officer of railways when nationalisation was introduced, said that it was time to get on with the installation of the system. But from nationalisation in 1948 until 1952, there were experiments and little else. It was then stated officially that four years had been taken to bring the prototype equipment up to "its present advanced state." The Great Western system had been rejected.

Answering a parliamentary question on January 26, 1953, the then Minister of Transport had said that there must be experiments; not experiments running into years, but probably some six months or so of hard investigation as to how far the production types of A.T.C. were proving effective. Three years later, on January 25, 1956, in answer to another question, the Minister of Transport said that the system of A.T.C. used on the Great Western Railway had certain technical disadvantages which precluded its universal adoption on British Railways, especially on electrified lines, although it had been very successful under steam operation. The British Transport Commission had produced an improved system which had reached an advanced stage of development. A pilot system was about to be installed on a really workable length of main-line railway.

The Minister had said in the 1956 reply that the main objection to the system in use on the Western Region was that it could not be applied on electrified lines, but it was noticeable from the report of the chief inspecting officer that A.T.C. had not been thoroughly tested on electrified lines. It was stated in that report that approval of the apparatus as adapted for use with the Westinghouse air brake on multiple-unit electric trains must await the result of trials which were soon to be put in hand. That was 16 or 17 months ago, but the trials had now been put in hand on an electrified line and, he hoped, would work out well.

GETTING THE BUGS OUT

In his reply to the debate, Mr. G. R. H. Nugent, Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation said that in the past 46 years there had been 698 formal inquiries into railway accidents and that 1,599 persons had been killed in those accidents. In the judgment of experts, about 11 per cent of the accidents referred to could probably have been avoided if automatic train control of the warning type had been fitted. Further, if that percentage of accidents had been prevented, about 31 per cent of the fatalities would have been avoided.

There were other features of special safety which went with A.T.C. One was track circuiting, by which the track was divided into sections insulated from each other. Trains entering a section short-circuited the low-voltage current and operated a track relay. The result showed in the signal box and formed the basis for many safety signalling functions. Colour-light signals were also used. They, too, had many advantages. A.T.C., track circuiting and colour-light signals, each a valuable safety device, could eventually be linked up to provide maximum safety, but the human element remained. Drivers and signalmen would still require to use their skill and expert knowledge.

The Great Western Railway's system, started in 1905, was a great achievement. It was during the 1930's that the Hudd system, a non-contact magnetic system, was evolved. Tried out on the old London Midland and Scottish Railway, it was not approved by the Minister of Transport until 1947. The British Transport Commission decided in 1948 that the A.T.C. system adopted was to be one which would combine the best of both the systems mentioned.

The Commission was convinced that it could find a better non-contact magnetic system than the Hudd. Initial trials were carried out in 1949 and, from 1950 onwards, full-scale trials were carried out on the East Coast line. There was no record of how long the Great Western system took to establish. The Hudd system took ten years. The seven-and-a-half years for the Commission's system was not an excessive time to—as the engineers put it—get the "bugs" out of a new system of that kind.

NO ELECTRICITY BOARD STAFF

In view of the shortage of staff on British Railways on the installation side, Mr. Goodhart had suggested that the Commission should approach the area electricity boards for assistance. On this aspect of the problem, Mr. Nugent said that that suggestion conflicted with the general policy of the railways—that their railway signal engineers never allowed outside contractors to undertake work on existing systems where the lines were in operation. Contractors were brought in to undertake new work, a complete new installation, but the danger of an outside contractor inadvertently doing something which interfered with the existing safety system was too great to be risked.

Capital restrictions were in no way slowing down the installation of A.T.C.; in fact, the Commission hoped to accelerate matters.

EUROPEAN INTER-STATE COUNCILS

No special arrangements have so far been made for British observers to attend meetings of the new Joint Assembly of the European Coal and Steel Community, the Common Market and Euratom. Mr. Ian Harvey, Joint Under-Secretary of State for Foreign Affairs, said that, until the new assembly had adopted its rules of procedure, no information would be available as to the extent to which its meetings would permit the attendance of observers. The head of the United Kingdom delegation to the High Authority of the European Coal and Steel Community, he told Mr. Henry Hynd (Labour), would be attending those parts of the assembly's inaugural session on March 19 which were open to the public.

On the general question of whether the British representative to the European Coal and Steel Community would also be accredited to the other two organisations, in view of recent developments in regard to the closer co-operation of all three bodies, Mr. Harvey pointed out that no site had been chosen yet for the institutions of the European Economic Community and of Euratom. Until that matter had been settled, any decision by the Government on how relations might best be conducted with these various Communities would be premature. Meanwhile, British embassies in the European capitals where meetings of the institutions of the European Economic Community and of Euratom were taking place were in touch with the organisations concerned.

Earnings and Population in Europe

Information available from the various reports issued by the Organisation for European Economic Co-operation indicated, said Sir David Eccles, the President of the Board of Trade, that between 1950 and 1956 the population of the non-sterling group of O.E.E.C. countries grew by 6·3 per cent and that of countries in the European Economic Community by 5·1 per cent. During the same period, gross national product per head of the population, based on current market prices, increased by 67 per cent in the non-sterling group of O.E.E.C. countries and by 73 per cent in the countries of the European Economic Community. The year 1950 had been chosen as being the earliest post-war year for which reliable figures were available.

Employment in Northern Ireland

Discussions have recently taken place between the Prime Minister of Northern Ireland and Mr. R. A. Butler, the Home Secretary and Lord Privy Seal, regarding the employment situation in Northern Ireland. Mr. Butler told Mrs. Patricia McLaughlin (Ulster Unionist) that he was in consultation with other British ministers respecting ways in which it might be possible to assist the Government of Northern Ireland in dealing with the problem.

Iron and Steel Board's Report

The annual report of the Iron and Steel Board for 1957 was expected to be submitted to him early in the coming summer, Mr. Reginald Maudling, Paymaster-General, told Mr. A. M. F. Palmer (Labour/Co-operative). As to suggestions that steel producers were being too cautious in their development policy, Mr. Maudling pointed out that judgment as to the exact level of the demand for steel in five or six years' time was open to a very wide margin of error. It was important that the country should have in mind not only the views of the steel industry but also, very much, those of the Iron and Steel Board.

Brussels World Fair

The area of the British Government's section at the Brussels World Fair, for which the Secretary of State for Foreign Affairs is responsible, will amount to about 70,000 sq. ft. In addition, Sir David Eccles told Mr. Sydney Irving (Labour/Co-operative), there will be a British industry section of 140,000 sq. ft, including a pavilion providing over 60,000 sq. ft of indoor exhibition space. Within that pavilion the Board of Trade is responsible for an area of 2,333 sq. ft. The department's direct financial contribution to the fair will consist of the provision, at an estimated cost of £40,000, of a display staged in association with the United Kingdom Atomic Energy Authority.

Marketing

TRADE FAIRS UNDER SCRUTINY

A most interesting statement was issued by Sir David Eccles, the president of the Board of Trade, on the Government's attitude to trade fairs and exhibitions. This was in reply to a parliamentary question requesting information on the Government's attitude to the present practice and policy on overseas trade fairs and on their reaction to the report of the Exhibition's Advisory Committee submitted last July.

Sir David announced that he had accepted the Committee's conclusions "in principle" and proposed "to act on them as the occasion arises, within the limits of the money available." He circulated a summary of the conclusions with his reply, and it can be assumed that this will now form the framework of Government policy. It is also clear that the Committee will continue to sit and give the Board further information and advice. Other bodies, including the Federation of British Industries, are studying the question and there should soon be ample data to guide manufacturers in the formulation of their own attitudes.

The Committee conclude that the Board of Trade should continue to provide information about trade fairs and provide official stands and displays wherever possible: "in overseas fairs where official Government stands are installed it is not sufficient for the United Kingdom to provide mere inquiry desks—a stand with a display is essential." They place great emphasis on the need for consultations with trade associations in the capital goods industries, whose co-operation should be sought for the organisation of displays "on a single industry or group of industries." Sir David Eccles' reference to "available" funds was doubtless in answer to the recommendation that the Board of Trade should bear the main cost of these stands, although the industries concerned will be expected "to lend exhibits free of charge and normally to pay for transport and for expert staff where their attendance is necessary."

The question of specialised trade fairs has been examined by the Committee, who consider that if the results of joint participation of industry and Government are found to be successful, "this participation should be increased." Most seasoned exhibitors will agree with the statement that, in fairs organised on the basis of national pavilions, this country will be outclassed and British manufacturers will not have the same opportunity as their foreign rivals "unless a contribution is made from public funds to the cost of organising a pavilion." The responsibility for this work is placed squarely upon the Board of Trade, who will now find themselves more deeply involved in the promotion of British goods abroad, particularly capital goods, than ever before. This is the inevitable conclusion that observers must draw if they have witnessed the performance of those countries who are gradually gaining at Britain's expense in export markets. During the next few years exports will increasingly assume a political function, in so far as they will be the principal means to exert influence over countries subjected to the rival pressures of political systems. Exports of machines and plant will take the place of armaments and the engineer of the soldier. In such circumstances no Government can afford to remain aloof.

Appliances and Atoms

Quoting the findings of the Federation of British Industries inquiry on the future of trade fairs, the manager of the Domestic Equipment Trades Fair, Mr. H. R. Mallett, called for the wholehearted co-operation of manufacturers. He has received a great deal of support for the widening of the fair "sufficiently to allow for the grouping of the products of allied industries." Exhibits have been invited from manufacturers of domestic equipment in the electrical, gas, oil, solid fuel and hardware industries, and Mr. Mallett now looks for practical evidence that the promises made by manufacturers and trade associations when they were sounded before the project was launched will be kept.

No such doubt appears to be in the minds of the organisers of the second International Exhibition of Atoms for Peace to be held in Geneva during the first fortnight in September. Already it is assured of being "a very great success." The closing date for reserving space has been fixed at March 31 and more than 11000 square metres have been booked so far. British industry will be staging "an impressive representation of its achievements" and some 50 to 60 firms will occupy over one-third of the area booked so far, i.e., over 4000 square metres. The newer industries appear keener to show their wares than the old-established. Their example, in the competitive climate of to-day, is well worth following.

Export Trade and the Government

Government-to-Government sales were discussed by the Minister of Supply, Mr. Aubrey Jones, speaking as guest of honour at the luncheon of R.C.E.E.A. in London. The subject was dealt with in the broader context of the Government's responsibilities for the electronics industry's future, which is now being threatened by major cuts in the Ministry of Supply's expenditure on development and by the reduction in the country's military aircraft programme.

Mr. Aubrey Jones confirmed that the Government, chiefly through the Ministry of Supply, in fact sell electronic equipment abroad, "either separately or complete with aircraft, ships or tanks, whatever they may be." He pointed out that some foreign governments prefer to deal in this way and therefore, although he personally was not particularly in favour of Government sales, it was important not to lose opportunities through being inflexible. The United States and French Governments were quicker to fall in with Germany's request that negotiations for the purchase of aircraft should be on a Government-to-Government basis. Yet Mr. Aubrey Jones said he did not "particularly want to do Government sales." Perhaps this is a mistake, to act only when forced to. There may yet be a time when the Government becomes a most important exporter (and promoter) of British goods.

B.E.A., the Jets and Exports

The chairman of the British European Airways Corporation, Lord Douglas of Kirtleside, writing in the February issue of the B.E.A. magazine, expressed his confidence that the Corporation's decision to place their order for 24 short-haul jet transports with de Havilland would result in export trade for Britain. The Corporation's decision was due to their belief that the DH 121 would be the better aeroplane "primarily because of de Havilland's unique background of experience with jet transports."

Lord Douglas pointed out that Britain's "ambitious programme of transport aircraft development" undertaken after the war has failed to achieve its aim—to put a large number of British airliners on the world's air routes. Less than 300 fully competitive modern airliners had been put into commercial service during that time compared to more than 2,000 new American aircraft. Only the turbo-prop Viscount had achieved any real success, and this was "designed and developed as a short-haul aeroplane specifically to B.E.A.'s requirements." Lord Douglas now expects the Corporation's practical experience in short-haul flying to result in a fully competitive jet aircraft with good export prospects. Similarly, B.O.A.C.'s assistance should make the long-haul VC 10 airliner a world beater.

Driving for the Canadian Market

The official attempts to increase trade between the United Kingdom and Canada are being followed up most energetically by some organisations. At a recent meeting with the Dollar Exports Council, representatives of the Scientific Instrument Manufacturers' Association of Great Britain decided to send a team to tour Canada. Led by Mr. L. A. Woodhead, a director of Cossor Instruments Limited, the team will tell Canadian industrialists of the latest developments in their industry and make the personal contacts which are so important to the successful development of exports.

The British journal *Commonwealth Calling* will carry a Canadian trade section giving information on how to build up trade with Canada. The first of these, which will be reprinted and distributed to 10000 firms in Britain, has an introductory article by Sir David Eccles. Specialised information of this kind is badly needed to encourage British manufacturers to export, but it must be factual and specific, dealing in actual experiences of exporters, market potentials and opportunities.

New Cost Cutting Techniques

The Retail Management Conference, which is to be held at Eastbourne March 18 to 20, will be addressed by Mr. Gottlieb Duttweiler, head of the Swiss MIGROS Organisation, the largest food distribution business in Europe. In 1927 he started delivering food using five model T Fords as mobile shops and selling basic consumer goods as much as 30 per cent. below current prices. Boycotting by suppliers led him to start his own food factories and he now owns 17 factories, 327 shops and 88 mobile stores.

The British Institute of Management, who are organising this three-day conference, will have other guests from overseas, including Professor Samuel C. McMillan, of the University of Connecticut who will talk on marketing management in the United States. The theme is "New Techniques in Retailing" and the conference should prove most stimulating and instructive.

Counter-Slump Advertising

United States Industry's answer to falling demand there is to intensify advertising. This emerges quite clearly from the statistics of expenditure in 1957. Some 10400 million dols. was spent, an increase of 5·3 per cent. on the 1956 figure. Both national and local advertising shared in the increase but the former gained more, the total reaching 6400 million dols. Large companies apparently stepped up their advertising more than those with a local coverage.

Interesting features about the advertising media were the large gains made by radio, up 14·3 per cent. Advertising on television networks also gained substantially, but far less than in former years. Magazines, which include trade journals, gained more than newspapers (though the latter are still the principal medium in the country) accounting for 3300 million dols. or about one-third of the total. There is a very different attitude from that in this country, where managements tend to cut down advertising as soon as the order intake falls off. But the techniques of advertising goods, particularly capital goods, are changing. The moment will come when the technical journals will change their familiar look because engineering products will be advertised in a very different way. It will arise from the better understanding we have of the motives of buyers, and of their needs.

Metals and Materials

MODERN TRENDS IN GALVANISING

The hot-dip galvanising industry is a traditional one and despite many technical improvements, the few, and, in some ways, simple processes involved have not fundamentally changed since their inception. In contrast, however, the industry has made great advances in the field of productivity, in plant layout, in materials handling methods and equipment, and in the more efficient use of its apparatus and personnel.

This has come about through the foresight of the industry's leaders who, in 1954, extended the activities and technical work of the Hot Dip Galvanisers Association to include a productivity service for its members. This service, started with the assistance of Conditional Aids funds, allocated by the Board of Trade and made available until the autumn of 1956, has since been continued with finances from the industry.

The productivity service is conducted by two qualified industrial engineers and carries out work-study investigations in members' firms, prepares publications on various aspects of productivity, arranges training courses and conferences, and provides films and an advisory information service.

A black and white sound film, entitled " Work Study—Its Application to Team Work," made with the co-operation of the British Productivity Council, was shown in London recently. This depicts how special work-study techniques can improve team work and complex operations in galvanising works in just the same manner as in repetitive and simple operations.

To supplement the practical work, a series of manuals on various aspects of productivity are published at intervals by the Association. The latest of these are *General Galvanising—A Manual of Good Practice* and *General Galvanising—A Manual of Costing Practice*. The first manual (price 25*s*.) outlines recommended technical and practical methods for achieving good galvanised coatings, in which methods the results of research work and the latest practical experience of specialists in the industry are combined. The manual has been prepared particularly for the use of shop-floor supervisors and leading hands. The main object of the second work is to focus attention on the importance of cost finding in increasingly competitive conditions and to give practical guidance on the subject. This manual is in two parts and the cost of the two volumes is 35*s*. A third work, *General Galvanising—A Manual of Good Housekeeping and Safety*, is in an advanced stage of preparation and two further manuals, *Materials Handling in the Galvanising Industry*, and *Work Study in the Galvanising Industry* are planned for future publication.

Copies of the works published and particulars regarding the loan of the film referred to above may be obtained on application to the Hot Dip Galvanisers Association, 34 Berkeley-square, London, W.1.

DEMINERALISATION OF WATER BY ION EXCHANGE

Prior to 1950 every power station in this country was equipped with triple-effect or unit-type feed evaporators for the treatment of the make-up feed water to the boilers. Since that date, however, very few evaporators have been installed because the new power stations have been provided with plants in which the demineralisation of the water is effected by ion exchange. Elaborating these statements, which were made in the course of his presidential address to the Society of Engineers in London on February 3, Mr. Robert Clark said that the change to demineralising plants had come as soon as silica-removal resins had been made available. Power stations were not alone in their use of the new technique. It had been adopted in the boiler houses of many large industrial plants such as steelworks, chemical works, textile factories and paper mills. In fact, demineralisation, in some form or another, was used with boilers operating from 200 lb to 3500 lb per sq. in. Its employment at present far exceeded other types of treatment formerly in common use.

It has also been used in the manufacture of fluorescent tubes: the coating of the tubes was imperfect owing to the deposition of mineral salts, and demineralised water was employed for the washing of the tubes. Following in sequence, manufacturers of cathode-ray tubes, wireless valves and transistors had all adopted demineralised water as part of their processes.

For special papers used in the electrical industry and filter paper utilised for analytical purposes, and in the field of fine chemicals and biochemicals, demineralised water was being extensively employed. In the realm of textiles the modern fabrics required good-quality water for their processing. For example, it was necessary to employ silica-free demineralised water in the manufacture of nylon.

Another sphere in which the ion-exchange technique was employed was in the treatment of the effluent from coke ovens. In the Corby ion-exchange process the raw effluent water was first treated to remove free and fixed ammonia. It was then successively subjected to clarification in settling tanks, cooled by rack-type coolers, filtered, treated by an ion-exchange process to remove thiocyanates and thiosulphates and finally treated with activated carbon for the removal of phenols, resins and colour-forming bodies. The quality of the final effluent was acceptable to river boards which set a very high standard.

HARD TIMES FOR SOFT WOODS

Last year one of the main features of the timber market was that European resources were drawn on more heavily than in earlier years. The chief reason for this decreased use of overseas supplies was the high ocean freight rates at the beginning of the year which made the marketing of Canadian timber in Europe difficult. This is one of the points made in the latest issue of the *Timber Bulletin for Europe* published by the Food and Agriculture Organisation. Rising costs of labour and manufacture in the principal timber exporting countries reduced the profit margins of the sellers during the year. Resale prices on the other hand did not rise sufficiently to absorb the increases in costs so that the profits of importers also fell. Exporters who find themselves with reduced operational stocks of both raw material and sawn wood are now having to replenish them by buying.

On the small-sized round-wood market price reductions have been recorded in Swedish and Soviet pulpwood and pitprop sales to continental Europe. Consumption of sawn wood production is being maintained at the 1956 level, but as exports by European countries show a slight increase there has been a reduction in millstocks. Stocks held by importers have, however, been maintained.

Export prices of sawn softwood remained practically unchanged throughout 1957. The bulletin finds it somewhat difficult to understand the small size of the price increases recorded at the forest auctions in the northern countries, especially as other costs besides raw material have also gone up during the year. The bulletin concludes that given the difficulty of reducing the cost of labour and raw materials, a more rational and cheaper distribution system obviously seems to be one of the few possibilities which could bring some relief to the trade's financial situation, and prevent a further rise in the consumer price of timber.

TOUR OF A SHEFFIELD WORKS

After a brief historical survey, a 16 mm. sound cinema film in colour, entitled " Tour of the Works," shown in London recently, depicts the main departments of the Sheffield Works of Thos. Firth and John Brown Limited, revealing some of the manifold operations involved from the melting stage to the dispatch of the finished products. The works are over 80 acres in area and comprise a fully-integrated manufacturing unit for the melting, forging, rolling, heat treatment and machining of an extensive range of forgings and rolled products in carbon and alloy steels. The film takes 33 minutes to run.

The film has been produced by the photographic section of the Brown-Firth Research Laboratories and commentaries have been recorded in French and Spanish as well as English. Copies are available on loan, free of charge, on application to the sales promotion department of the firm, Atlas Works, Sheffield, 4.

COLD PHOSPHATING OF STEEL SHEET

A new phosphating process for direct application to clean sheet-steel surfaces prior to painting has been developed by the Walterisation Company Limited, Purley-way, Croydon, Surrey. To be known as the firm's SPC process, from Spray Phosphate-Cold, the treating solution, which is furnished at the correct strength and applied to the work by means of a spray gun of the type employed for paint spraying (but the working parts should be made of acid-resisting material). An air pressure of between 30 and 40 lb per sq. in. should be utilised and the solution must be held in a glass or acid-resisting container.

The technique of application consists simply of degreasing, phosphating, washing and drying and the part is ready for immediate painting. Degreasing is carried out by wiping with white spirit, trichlorethylene or other organic solvents. The surplus liquid is wiped off and the component allowed to stand for 5 minutes. The SPC solution is then sprayed on to the surface so as to wet it completely. It is allowed to remain in contact with the steel surface for five minutes and is then washed off thoroughly with clean water and the surface wiped and finally dried for painting by means of warm air or an oven. The phosphate coating produced is very fine grained and its weight should be between 40 and 80 mg per sq. ft.

The process, it is felt, should be of particular value for repair work where phosphate coatings have had to be removed locally for welding or other treatment.

Research and Development

CONSISTENT RESULTS IN HARDNESS TESTING

*New Machine at National Physical Laboratory**

By R. S. Marriner and F. C. P. Mason

To obtain the correct diamond-pyramid hardness number of a specimen the indentation should be made by the penetration, at a slow uniform velocity, of a perfect diamond-pyramid indenter, the axis of which is perpendicular to the polished surface of the specimen. The final force on the indenter, the motion of which must be in the direction of this axis, should be equal to the prescribed load.

In practice, these ideal conditions are difficult to achieve and in order to eliminate some of the sources of variation and to minimise others a new standard indenting machine has been constructed with loads in the form of dead weights which are freely suspended from the indenter. The general form of the machine may be seen in Fig. 1, while Fig. 2 is a simple diagrammatical illustration of the essential components. The machine is completely enclosed in a case of hexagonal shape surmounted by Perspex windows and is operated by controls housed in a separate cabinet.

* Communication from the National Physical Laboratory, Teddington, Middlesex. (Abridged.)

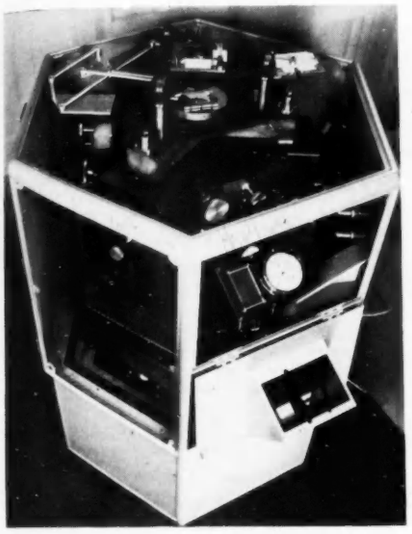


Fig. 1 New standard indenting testing machine enclosed in a case of hexagonal shape, shown with the Perspex windows and two outer panels removed.

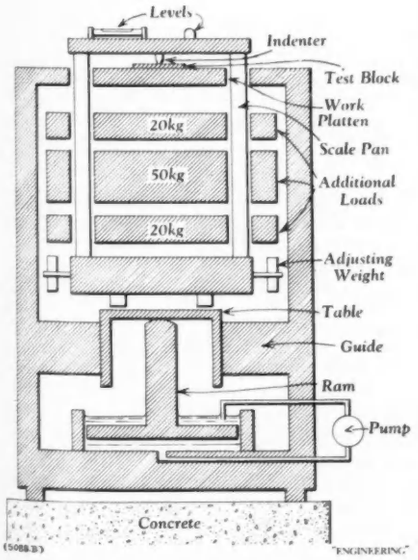


Fig. 2 Diagrammatic illustration of the scale pan, indenter, test block, work platten and other essential components of the machine.

The smallest standard load, to which the indenter is rigidly attached, is in the form of a scale pan and the dead weight of this is the required 30 kilogrammes-force within $\pm 0{\cdot}001$ kgf. This scale pan consists of two triangular shaped castings, heavily ribbed to prevent distortion, and separated by 1 in. (25 mm.) diameter rods at the corners of the castings. The top surface of the scale pan, to be seen at the top of Fig. 1 and in Fig. 2, carries two level-tubes mounted mutually at right angles and having a sensitivity such that one division (0·1 in. or 2·5 mm.) is equivalent to 3 seconds of arc tilt. The base of the scale pan is fitted with three cylindrical feet of diameter 1 in. (25 mm.), the finished end faces of which are co-planar so that the pan may stand on the flat top surface of a ground table of cylindrical form which can move vertically in rigid, lapped guides (see Fig. 2). During the initial assembly of the machine, the top surface of this table was set precisely in a horizontal plane by adjustment of ground packing pieces between the base casting of the machine and its steel foundation, which is set in a robust concrete plinth about 24 in. (610 mm.) deep.

The vertical movement of the table is controlled by a hydraulic ram which is fed by a small variable delivery pump of the swash-plate type running at a pre-set constant speed. The hydraulic ram consists of a 2 in. (50 mm.) diameter shaft running in Oilite bearings and this shaft is integral with a 10 in. (254 mm.) diameter piston which moves in a ground cylinder having a diametral clearance of 0·001 in. (25 μ) with respect to the piston. The space above the piston constitutes the reservoir for an oil of suitable viscosity, and the movement of the table and scale pan is effected by slowly pumping the oil from above to below the piston and vice versa.

Owing to the large diameter of the piston and the small delivery of the pump, velocities of a few ten-thousandths of an inch per second can be achieved readily and the movement of the ram is completely free from "stick-slip" phenomena because of the small but significant clearance between piston and cylinder. An appropriate choice of hydraulic oil ensures that the leak past the piston is constant regardless of the load on the scale pan, and constant velocities of the ram between zero and a few hundredths of an inch per second are obtained either by setting the swash plate of the pump or by changing its speed of rotation. The latter can be increased, almost instantaneously, by a factor of nine, by moving the variator control lever situated at the top of the adjoining control cabinet and this is used when rapid traversing of the table is required.

With the scale pan initially standing on the cylindrical table (Fig. 2), the level-tubes on the top are adjusted in their mounts to read zero and a dummy test block is placed under the indenter on the robust work platten. The table is then lowered at the rate of about 0·001 in. (25 μ) per second and eventually the scale pan breaks contact with the table and remains freely suspended, pivoting on the indenter only. Unless the machine has already been adjusted the scale pan will swing slightly, in which case the position of the three balance weights, disposed symmetrically about the base of the scale pan, are adjusted so that the level-tubes again read zero. This adjustment ensures that the plane of the feet is again horizontal and that the scale pan can now be picked up by the table without tilting it. It is found in practice that, after this adjustment, any number of indentations can be made with agreement between the level readings, before and after the transfer of the scale pan, within 0·1 division, i.e., within 0·3 second of arc.

When freely suspended on the indenter, the scale pan is extremely sensitive to minute external forces, but vertical fins attached to its base and permanently immersed in dash pots filled with a thin oil prevent any oscillatory swing or rotation of the scale pan immediately after the transfer of the load from the table to the indenter. These fins do not exert any restraint on the indenter during the period of penetration as the scale pan is in contact with the table, and is entirely controlled by it, until the whole load has been transferred.

As illustrated in Fig. 2, the three additional loads are supported by the main framework of the machine between the top and bottom members of the scale pan. These loads, which are correct within $\pm$ 1 gramme-force, are in the form of hexagonal plates and some or all of them may be picked up by the scale pan to produce the standard dead weight loads of 50 kgf, 100 kgf and 120 kgf.

To assist in the operation of the machine a number of accessories have been added. A glass scale, graduated in hundredths of an inch, is attached to the table and is projected, at a magnification of about 20 times, on to a screen at the front of the machine. The projected image of the scale can be read by reference to a fixed line engraved on the screen so that the observer is able to see at a glance where the scale pan is located with respect to the test block or the additional loads. By timing the passage of graduation lines past the fiducial line the rate of descent of the table can be determined and the hydraulic pump set to give any desired rate of penetration. A system of mirrors suspended over the top of the scale pan produces images of the two level-tubes that can be seen from the front of the machine. The operator is thus able to view both level-tubes simultaneously, which facilitates the initial balancing of the scale pan and enables him to check that perfect balance is being maintained throughout each indenting operation. In addition, there is attached to the top of the table a pneumatic gauging head comprising a small jet, the air escapement from which impinges on the base of the scale pan while the latter stands on the table. The pressure behind the air jet is displayed on a pressure gauge beside the image of the glass scale and indicates, by a sudden change of reading, the precise moment when the scale pan leaves the table.

A further accessory is a pantograph mechanism which moves the test block between indentations by means of an arm remote from the machine. This pantograph facilitates the precise location of indentations at pre-determined positions on the test block and has assisted in establishing correlation between hardness and differences of microstructure in localised areas.

A method of hardening, grinding, and polishing test blocks made from a plain carbon steel was devised which, from an examination of their microstructure, appeared to produce blocks of uniform structure. Test blocks were then made over a period of months and some of them were subjected to a stabilising treatment for different lengths of time to obtain various levels of hardness. Finally the surfaces of the blocks were highly polished. In the expectation that all the blocks would be uniform in hardness, five randomly-disposed indentations were made on

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Research and Development

each with a load of 30 kgf, the indentations measured and the hardness values determined by interpolation in the tables in BS. 427 : 1931.

It was found that the range of hardness value obtained for each block was small and, bearing in mind the small number of indentations made, that it was not significantly different for the 13 blocks. Whether the source of the major part of the variation found arises from the indenting machine, the measuring microscope, or the blocks themselves is immaterial for standards work, provided hardness values as uniform as these can be obtained consistently at all the required levels of hardness and provided also that there is no systematic change in the mean value of the standard with time.

It was further found that the results from 30 indentations distributed over a period of six weeks, agreed remarkably well with those from an initial 34 indentations in both mean and range, and that the mean of five indentations gave a very good estimate of the mean hardness value, regardless of the observer employed.

The precision disclosed by these, and other experiments, indicates that the new standard indenting machine and prototype measuring microscope are adequate for transferring a sufficiently accurate standard of hardness to industry provided there is no systematic secular change in the standard given by the machine.

INVENTIONS TAKE SHAPE

In the eight years of its existence, the National Research and Development Corporation has received and considered over 6000 inventions, and they are still coming in at the rate of 12 a week. At the same time, on the average, one invention per week is being handed over to industry in a form that can be used directly. The eleven that fall by the way do not all do so by lack of merit; many of them have to be refused under the charter.

At a Press conference held to review the annual report,* Lord Halsbury, the managing director, outlined some of the work in hand. Among the many items mentioned were computers, potato harvesters, a regenerative mechanical transmission, and frozen milk and cream. A business-type computer was undergoing trials in a stores handling many hundreds of components.

It was hoped that a bus using the regenerative transmission would be on the road before the end of 1958. In this system, when the vehicle is braked the greater part of the energy is absorbed in accelerating a 2 cwt flywheel mounted under the floor of the vehicle, and only the last deceleration is performed by the brakes themselves. (This is roughly equivalent to greatly increasing the braking effect of the engine.) Then when the vehicle is restarted the energy of the flywheel is used to accelerate it, resulting in a saving of fuel. Theoretically the saving could amount to 50 per cent., but in practice it is expected to be something over 5 per cent.—a worth-while amount for the large operator. There is also a saving in wear on brake linings.

In quite a different field is the process whereby freshly pasteurised milk and cream can be treated with ultra-sonic waves, poured into polythene bags and frozen. Milk frozen in this way has been supplied to some shipping lines and samples of cream have been kept for six months without deterioration. Work on a parallel subject—the smoking of kippers—continues steadily.

Twelve projects are reported on for the first time. They include leaching by organic reagents; extraction of metals by ion exchange resins; and the towing of flexible oil barges. So far the last have been made of rubberised nylon as big as 40 tons capacity.

* Report and Statement of Accounts for the year July 1, 1956, to June 30, 1957. H.M.S.O. 2*s*.

Design

RECENT TRENDS IN ELECTRIC TRACTION*

By R. S. Wignall, B.SC.

The trends of development in electric railway traction are broadly divided into four groups: Diesel and Gas-turbine Traction, Electrification, Trackwork, and Train Performance Determination. The last of these, although theoretical, cannot be divorced from a review of modern traction.

DIESEL TRACTION

In 1950 there were only 160 diesel locomotives on the main railways in Europe and Africa. In 1956 there were over 2500 units operating with a further 1000 on order and 6000 to 7000 required. Rapid progress has been made in the New Zealand Railways where 93 of their 136 diesel units have been delivered in the past two years.

1500 h.p. diesel-electric locomotive to operate in New Zealand on lines permitting low axle loads.

Diesel traction is not the answer to all operating problems; in Europe its development is naturally based on the economics of each case; it did, however, introduce much greater flexibility in traffic services. Many African and Colonial railways have been faced since the war with enormous increases in traffic due to major economic developments within their territories. They have invariably been operating steam motive power and found themselves severely handicapped by water supply and the cost of coal delivered to the place where it was wanted. They therefore found it essential to have a more independent method of traction better adapted for long runs, on lines of light construction, with frequent small radius curves, and severe grades. Accordingly, there has been a big demand for medium and high-powered diesel locomotives. This policy has been adopted in such countries as Rhodesia, Belgian Congo, Nigeria, Ghana, Tunisia, Sierra Leone, Algeria, Egypt, and French West Africa.

When an electric power supply for mining or industrial purposes is available, with a surplus for traction, there is some justification for electric traction. An example of this is in the Belgian Congo where routes have been successfully electrified at 25 kV a.c. Even in this area, diesel traction prevails where power supplies would be expensive and technically difficult to erect.

In the United States the trend of development is paramountly clear, and diesel traction will not in the next 20 years be displaced by electrification on a large scale. The advance has been spectacular and it is only because the American market is now nearly saturated that American salesmanship is making a marked impression on territories which were hitherto almost exclusive to European manufacturers.

LIGHT RAILWAYS

Many countries abroad have inherited great lengths of lightweight track, or track for which adequate maintenance has not been provided; here the maximum axle load will have a low value. In Australia on some of the more remote railways it is necessary to meet axle loads as low as 10 tons on 3 ft 6 in. gauge. This immediately limits the weight of a conventional locomotive to 60 tons, irrespective of horsepower.

Applications of this type are invariably diesel-electric or diesel-hydraulic (i.e., not electric) and the power unit can only exceed 1000 h.p. if the engine is of a lightweight pattern. This is, however, a major advance on 1939 practice when 400 h.p. was the largest power unit which could be installed within this axle load. Development beyond the present level is of little value as the maximum speed is usually governed by the track condition, and the adhesion limits the trailing load which can be hauled.

DIESEL ENGINES

Since the war the diesel-engine industry both in Europe and in America has realised that to promote sales of their products for traction it is necessary to improve the power/weight ratio of their engines. Both increased output and reduction in weight have enabled values of 13 lb per h.p. in the 2000 h.p. range to be achieved. Some of the methods employed are: (1) By high pressure supercharging and after-cooling. (2) By raising engine speeds, and thus piston speeds. (3) By rating engines more logically under abnormal site conditions than by rule of thumb methods. (4) By incorporating light alloy for lightly stressed components. The development of the exhaust-driven turbo-supercharger has advanced considerably since the war and, by providing ever-increasing forced aspiration and exhaust scavenging, it has been possible to increase the output of some diesel engines by 50 per cent. or more

These are factors which have enabled greater output to be achieved from existing basic designs. New designs of engines in use incorporate these features and examples are numerous in the range up to 500 h.p., with the Deltic pattern in the 1000 to 2000 h.p. range. All these newer engines have a specific weight less than 7 lb per h.p.

In modern diesel-electric locomotives, the diesel engine forms about 20 per cent. of the total weight. Of the remainder, the electrical equipment absorbs about 30 per cent., mechanical parts 40 per cent., and services about 10 per cent.

GAS-TURBINE LOCOMOTIVES

The three countries actively interested in gas-turbine traction are the United States, Switzerland and Great Britain. As early as 1930, Brown Boveri were investigating possible uses of the gas-turbine and included locomotives as one of them. In 1939 an order was placed by the Swiss Federal Railways for an experimental locomotive which was delivered in 1941. This unit had covered some 170000 miles by 1950, its use during the war being restricted by shortage of fuel. It was later modified in order to burn residual oil and this experiment was successful. In 1946 British Railways ordered

* Paper read before Section G of the British Association on September 9, 1957, at Dublin. (Abridged.)

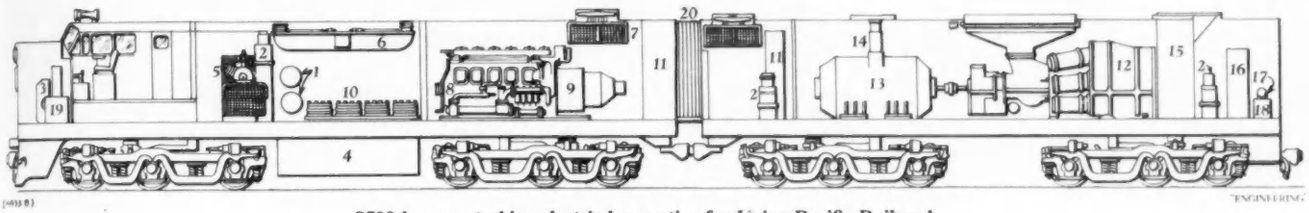
a 2500 h.p. unit from the same firm and this was delivered in 1950. (It runs on the heavy fuel mentioned above.) For starting and shutting down gas-oil is used and, because of the low efficiency of the turbine unit at low speeds, the auxiliaries are provided with power from a small diesel engine. Electric transmission between the turbine and the road wheels is used on all these units and is similar to that of diesel-electric locomotives of the same power output.

A British manufacturer has developed a 3000 h.p. gas-turbine locomotive, almost the entire machine being manufactured by the one company. The turbine burns gas-oil and later attempts to burn heavy oil were not very successful.

The Union Pacific Railroad in the United States has undoubtedly had the greatest success with gas-turbine units, and their experience with them dates from 1948. Several firms produced prototypes and the General Electric Company were successful in obtaining an order for ten 4500 h.p. units. In 1952 a second order for 15 was secured. These locomotives have proved themselves well adapted to handle heavy high-speed freight trains. They have been used on a 1000 mile haul from Council Bluffs, Iowa, to Ogden, Utah, on a route which rises 6000 ft, and in ambient temperatures from 30° F. below zero to 100° F. above. A larger unit has been designed as a result of experience gained with the first units. This design has an output of 8500 h.p. (under site conditions); 30 are under construction.

In practical operation, these locomotives use full power for the long rising gradients, working at their maximum efficiency, and the turbine is shut down for long falling gradients, necessary power being provided by an auxiliary diesel engine.

Improvement in overall transmission efficiency has encouraged the development of mechanical transmissions. A mechanically-driven gas-turbine locomotive has been completed by a French firm, and a British firm has built a prototype also employing direct mechanical transmission; this unit is at present undergoing development tests.



8500 h.p. gas-turbine electric locomotive for Union Pacific Railroad.

1 Air reservoir
2 Traction motor blower
3 Air brake equipment
4 Diesel fuel tank
5 Air compressor
6 Braking resistance
7 Radiator
8 Auxiliary diesel engine
9 Auxiliary generator
10 Battery
11 Control cabinet
12 Gas-turbine
13 Traction generators
14 Generator blower
15 Gas-turbine exhaust
16 Fuel heating and filtering
17 Starting fuel pump
18 Coolant water tank
19 Train control
20 Corridor connection

ELECTRICITY

Power Supply

In order to electrify a line, it is not now necessary for railways to begin by producing their own power, except in some under-developed districts in the tropics. General power requirements have increased enormously in recent years, with requirements for traction rising much less rapidly. Generating capacity has increased in much greater proportion, and it is safe to say that there is no danger of the traction load in any territory causing embarrassment to the generating authorities.

To reflect for a moment on current practice; the spacing of traction substations varies with system voltage. With 1500 V direct current, they may be placed at intervals of 5 to 15 miles according to the type of traffic and the profile of the line. With heavy traffic the equivalent copper cross-section of conductor may reach 0·75 sq. in. By doubling the system voltage to 3000 V d.c., the spacing of substations will average 25 miles. For 15 kV at 16⅔ cycles supply, such as those in Central Europe, the substations can be placed up to 47 miles apart, the average now being about 37 miles. For overhead conductors, the cross-section is reduced to that necessary for mechanical strength—a typical figure being 0·15 sq. in.

Two systems in present use which are able to utilise widely spaced substations and light overhead conductors, are the Swedish system at 16⅔ cycles, and the French (and now British) system at industrial frequency (50 cycles) and 25 kV. The former operates successfully in Sweden but involves high substation costs for converting from 50 cycles three-phase to 16⅔ cycles single-phase.

The simplicity of providing a power supply at industrial frequency has been quickly realised in developing this system in France, Belgian Congo, Turkey, and latterly Great Britain. In France, on lines carrying very heavy traffic, they have installed simple substations at 28 to 31 miles apart, and for less heavily loaded lines this has been increased to 31 to 37 miles. On the section from Lille to Basle the average figure is 40 miles; while this was dictated by the supply points from the high voltage supply system, it was also the correct spacing required. Thus, the possible spacing between supply points in industrial-frequency electrification is sufficient to permit great latitude in substation siting and, in fact, this has enabled the French Railways to site some of their equipment within existing supply authority compounds. Potentially, this offers certain countries the opportunity of enabling the generating authority to supply the railway direct with 25 kV at industrial frequency.

Rectifiers

The developments in rectifiers have been mainly concerned with improving the mechanical details which were the principle source of breakdown in mercury arc rectifiers. The major source of trouble was undoubtedly the auxiliary gear necessary to operate large water-cooled continuously-pumped rectifiers of 1000 kW and above. Despite the complication of ancillary gear, these equipments were successfully used for such traction systems as the London Underground, and on the Natal line in South Africa. The latter application represented at the time probably the peak of development, some of their units being used on reverse operation for regenerative braking.

In the middle 1930's a British firm began manufacturing steel-tank rectifiers employing a satisfactory anode and cathode seal enabling a tank to be evacuated down to 0·1 to 0·01 micron after assembly. After sealing, the unit was ready for many years' operation without attention to the vacuum. This technique, now common knowledge and practice, represented at that time a major stride in steel-tank rectifier development. It also presented a more robust competitor to the glass-bulb rectifier which although of very limited individual rating is still widely used for traction substation applications. It is inherently unsuitable for vehicle mounting. Until 1950 most rectifiers were made with 3 or 6 anode arms per unit, firing into a common cathode pool. (Improvements in design using this form have aimed at smaller tanks for a given rating, improved cooling and improved anode seals; the increased ratings thereby obtained are now very near the limit for this type of construction.)

Developed about 1935 from the thyratron, the single-anode rectifier is finding much favour for traction purposes. Both the excitron and the ignitron (differing only in the method of excitation) are used. The ignitron employs pulse ignition every cycle by means of an igniter anode dipping in the mercury cathode; the excitron uses the conventional continuous excitation (supplied by an auxiliary d.c. source) throughout every cycle. Recent developments in France and America have shown that the use of single-anode rectifiers with d.c. traction motors is not only feasible but is an essential part of a single-phase 50-cycle traction scheme. One inherent advantage of the single anode unit is its compactness.

In Great Britain experiments commenced in 1952 with a poly-anode rectifier equipment on a short line between Lancaster and Heysham; in addition an air-cooled excitron type equipment is operating satisfactorily at present.

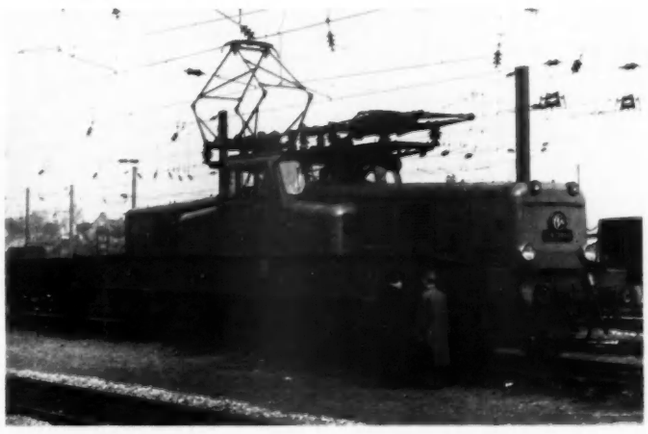
The "dry" or "metal" rectifier received little notice for traction until recently; considerable research into the use of silicon and germanium units has produced a practical rectifier comprising a large number of small, simple and inexpensive units. To dissipate their electrical losses, fins are usually incorporated and these limit the physical dimensions of the complete rectifier unit. Up to date they have been experimentally applied to one multiple-unit train in Great Britain.

Rectifier Locomotive

Until the end of the war the idea of carrying a rectifier unit within the locomotive had received little attention. On the Hollenthal railway in Germany an experimental locomotive had been built before the war but its complex auxiliaries associated with the continuously-pumped rectifier had given considerable trouble. The advent of the steel-tank pumpless rectifier eliminated most of their troubles, but its rating in comparison to its size restricted its use to multiple-unit trains. The introduction of the single-anode rectifier has forestalled the development of the poly-anode tank and there appears little chance of the single-anode unit being displaced in the near future.

The application of these units has been rigorously examined by the French and certain American railways, and the French have established an 84 tonne locomotive from which they have achieved a remarkable performance.

In 1952 the American Westinghouse company produced a prototype ignitron motor coach and two 6000 h.p. ignitron locomotives for the Pennsylvania Railroad. These were followed in France by an Alsthom locomotive with poly-anode rectifiers, and a converted motor coach using Westinghouse ignitrons operated experimentally on the Savoy line. The Alsthom locomotive is a 78 ton machine and is rated at 2840 h.p. (one hour); it has a maximum speed of 66 m.p.h. Soon after this, the rectifier locomotive emerged from the prototype stage and became current practice in the United States and France; the former, with ten 6000 h.p. units for the New Haven Railroad and the latter with 52 locomotives of the type seen on the 50-cycle lines in France to-day.



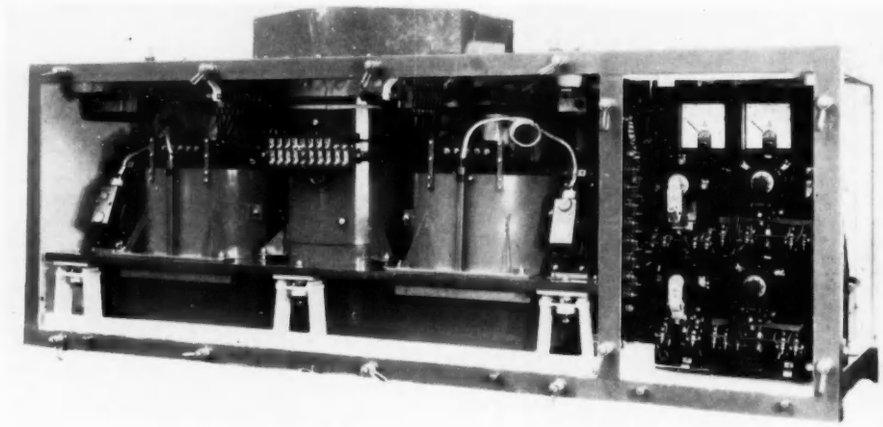
French Railways' 84 ton electric locomotive for operation on 25 kV a.c. routes.

There are two attributes of the modern rectifier locomotive that enable it to perform in the manner which the French have demonstrated. The main attributes of the modern

Continuing **Design**

rectifier locomotive—which have given it a somewhat outstanding performance—are that its traction motors are all connected in parallel and are under voltage control without the use of starting resistance. The design of mechanical parts is such that a very low weight transfer is obtained. Locomotives of this type weighing 84 tonnes are in service handling trains of up to 1750 tonnes on 1 in 100 grades. It remains to be seen whether similar results can be obtained in this country with rather different rail conditions.

Following the great publicity given to these units at Lille in 1955 and thereafter, many foreign railway systems have been injected with French propaganda, thus tending to stimulate the products of successful French manufacturers.



Excitron-equipment underframe for mounting on multiple unit stock.

Rotary Converter Locomotive

All the converter locomotives built in Hungary, the United States and Austria before 1935 were cumbersome because the rotating machinery had not benefited from the general progress towards lightness available for machines of similar outputs to-day. In 1951 the French Railways put into operation, on the Savoy line, a converter locomotive. This 112 ton six-axle locomotive rated at 3820 h.p. (one hour), in common with other converter locomotives, has the merit of improving the overall power factor on systems also using rectifier units.

The high cost of these locomotives is apparently justified from the good adhesion characteristics, easily controlled regenerative braking and the good power factor already mentioned. The very close control available for the traction motors enables about 55 per cent. greater loads to be hauled than with an equivalent six-motor d.c. locomotive. The application of these locomotives is claimed by the French to be most useful for the haulage of very heavy freight trains at low speeds, but the successful application of rectifier units in this field (e.g. in the lignite mines in Germany) would indicate that there is little future for this type of locomotive.

D.C. Electric Locomotives

The progress which has taken place in the design of d.c. electric locomotives has not attracted the public eye as much as other more novel forms of traction. This is probably because the d.c. unit had already reached an advanced level of development before 1939. However, with the ever increasing traffic and the higher speeds demanded on most systems, greater drawbar pull and horsepower have been required. Maximum axle loads have not risen at the same rate, and hence the problem is analogous to getting the proverbial "quart into a pint pot." Traction motors have increased in output with only slight weight penalty, but have not increased much in size since this is usually limited by the loading gauge. The nose-suspended motor (almost universally applied) has now more powerful windings incorporated in the same armature diameter, and improved mechanical design has allowed greater traction motor speeds to be attained. This increased power output is due to two factors: (1) Allowing the motor to generate more waste heat, which needs an increased volume of cooling air to dissipate the heat, and careful attention to the design of the air spaces within the motor to avoid hot spots. (2) New techniques and insulating materials enable more copper to be fitted into the same size of armature slots, whilst retaining the same insulation level.

The higher working temperatures mentioned have demanded impregnated materials; silicones or synthetic varnishes are to be found in almost all traction windings. At the same time solders capable of withstanding 180° C. without melting have come into common use.

Coincident with these developments, great interest has been shown by customer and manufacturer alike, in flexible gears and drives between the road wheels and the traction motor in order to reduce the unsprung weight on the axles.

The principal developments in the control gear associated with these locomotives have been in three fields: (*a*) The replacement of cast iron for starting resistances by alloy steel strip working at much higher temperatures. This has reduced the volume and weight of the resistance frames themselves but has been partly offset by the essential force ventilation equipment; (*b*) With the recently developed techniques and the wide variety of material now available, it is possible to select the right insulating material, in all respects, for each individual component. In this field, phenolic materials have come into common use for such items as potted coils and relay components. For resistance frame insulation, ceramic materials have replaced mica; (*c*) A trend towards lighter construction in relays and contactors without sacrificing the mechanical strength necessary to withstand traction duty has become evident.

TRACKWORK

Rails

1956 was the centenary of the Bessemer steel rail, for it was on August 11, 1856, that Henry Bessemer (before this Association) announced his process for making cheap steel rails. Even to-day manganese-steel rails similar to those produced 80 years ago are in use; medium manganese-steels are in use in Britain, Western Europe, and India; high carbon steel is used in America because of the higher axle loads involved.

Regarding the track layout itself, there is no doubt that the quest for higher speeds and longer, heavier trains coupled with higher values of adhesion, brings great forces to the track bed which are now counteracted by improved location of the track and strengthening of the bed.

Signalling

The most noticeable feature in the signalling field has been in the application and improvement of devices developed before 1939. Such devices are colour-light signals, power controlled layouts, Centralised Traffic Control (C.T.C.), plug-in relays, potted relays and alternating-current track circuits. A recent development is that of coded track circuits, and special frequency track circuits on lines using 50-cycle a.c. traction, or where there may be stray 50-cycle a.c. currents.

Automatic train control is no newcomer to traction, having been in continuous use on the Great Western Railway since 1905. The French Railways have also used a similar direct-contact system. The Hughes non-contact system is now being installed on main lines in Great Britain.

TRAIN PERFORMANCE

Before the war the locomotive manufacturers were building units of fixed horsepower and determining their performance by practical test after construction. The exception was multiple-unit electric stock, where limited calculations were made, by hand methods (slide rule), to pre-estimate the performance.

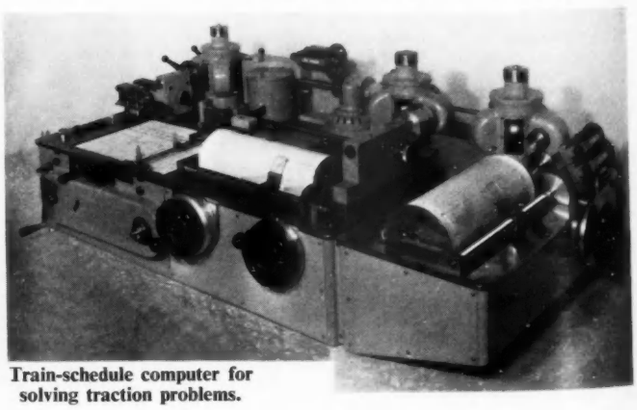
To-day, the manufacturer is expected to provide facilities for the accurate calculation of predicted performance for the products he offers. This not only assists the customer in the preparation of time-tables but it enables the manufacturer to offer equipment suitable to meet customer's requirements at minimum cost and with maximum reliability. Basically, the problem is that of moving trains from one place to another in a given time. The speed attained and tractive effort required are dependent on these quantities and on the track profile.

It is only possible to mention very briefly the methods employed. They all depend basically on Newton's Second Law of Motion. In 1951 the Pennsylvania Railroad used an electro-mechanical special-purpose computer in which the integrations were performed mechanically. Accelerating and retarding forces were represented by appropriate voltages. Another electro-mechanical computer has been developed by Professor Bradshaw of Manchester University. In this the integrations are performed electrically by watt-hour meters. A novel feature is that automatic curve-following of the characteristics is provided. A noteworthy computer is that manufactured by a Swiss firm for the French Railways in 1949. Although originally limited in its application, it has already been modified so that when finished it will be able to calculate and record traction motor temperatures.

A similar computer (developed by a British locomotive firm and the same Swiss firm) is now in operation on a wide range of traction performance problems. In common with the French machine, it is an analogue computer, the integrations being carried out by ball-type integrators. The main computer provides a graphical speed-distance record, over any prepared route, of the expected performance of any equipment for which characteristics have been plotted for the machine. In addition, the fuel or energy consumed can be calculated and recorded on a supplementary computer. This computer can also calculate and record the summated expression which is representative of the temperature rise in the electrical machines.

Some idea of the relative speeds of computation can be gauged from the following comparison of a typical calculation on the performance of a suburban electric train:—

By slide rule	2-10	Miles covered per hour of calculation time.
By analogue computer	20-100	
By electronic computer	600-6000	



Train-schedule computer for solving traction problems.

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Acknowledgments—The author wishes to acknowledge the permission of the English Electric Company to present this paper and to publish this extract.

OIL RESONANCE IN BEARINGS

Influence on the Whirling of Vertical Rotors

By Finn Örbeck, PH.D., B.SC., A.R.C.S.T.

It was shown by Stodola in 1925 that the oil films of plain journal bearings have quasi-elastic properties and, consequently, that a rigid rotor can come into resonance when supported by the oil film. Many investigators have studied this phenomenon, which is referred to as oil resonance, but the apparently non-linear characteristics of journal bearings present an obstacle which has strongly limited their results. When the whirling motion of the journal is caused by an out-of-balance mass, the centre of the journal will move in a circle about the centre of the shell. Further, since the force on the journal rotates with the same angular velocity as the shaft, the frequency of the whirling motion will be the same as the frequency of rotation. In this connection it is important to observe that, since the journal moves with a constant eccentricity, the resistance which the oil film offers to the journal motion will be constant throughout any cycle of whirl. Consequently, in spite of the non-linear characteristics of the bearing the whirling motion will have some features which are linear.

Previous analyses of oil resonance have generally been based on consideration of the whirling motion as being composed of motions in two perpendicular directions, thereby introducing the difficulty of non-linearity. In describing the motion by a rotating vector, however, it is in fact possible to avoid this difficulty.

Another feature which has brought complications into the study of oil resonance is the confusion which has occurred between oil resonance and oil whip. To distinguish the two phenomena it is most convenient to consider their frequencies. Oil whip, which is directly related to the property of an oil film, is a phenomenon which is characterised by being at half shaft speed, and is a whirling motion of the shaft near this frequency. Oil resonance, on the other hand, is a phenomenon which occurs when the frequency of an exciting force acting on the journal coincides with the natural frequency of the rotor supported by the oil film. The frequency of oil resonance, therefore, is constant, as determined by the physical dimensions of the rotor and the bearings, but the frequency of the forced vibration, which strikes oil resonance conditions, is related to the shaft speed according to the number of harmonics of the exciting force. When, as in the present case, the exciting force is due to out-of-balance conditions, the whirl at oil resonance will be of the same frequency as the frequency of rotation.

When the exciting force is a centrifugal force, it is possible to give a simple analytical treatment of forced whirl for a vertical rotor supported by journal bearings. If the rotor is flexible, the system will have a frequency response curve as shown by either of the two curves of Fig. 1, according to the amount of out-of-balance in the rotor. In the case of plain journal bearings, it is found that metallic contact will occur in the bearings at resonance if the ratio of the radius of out-of-balance of the rotor to the radial clearance of the bearings is larger than 0·4. The critical value of this ratio is independent of the stiffness and the mass of the rotor.

The rotor under consideration would have a natural frequency of whirl of 68·7 sec.$^{-1}$ if simply supported at the bearings. For a radius of out-of-balance of 2×10^{-3} in. this value would be 62·5 sec.$^{-1}$ when the bearing flexibility is taken into account, i.e., a change of about 10 per cent.

To investigate the case of oil resonance the frequency response curves were calculated for a rigid rotor. These curves are shown in Fig. 2. It will be noted that a closed resonance peak is obtained as before for the smallest value of the out-of-balance, but, as would be expected, the resonance frequency is much higher than before. For high values of the radius of out-of-balance there is no distinct resonance peak.

Photocopies of the complete paper, of which the above is a digest, are obtainable from the Publisher, ENGINEERING, 36 *Bedford-street, Strand, London, W.C.2. Price 25s. each, post free.*

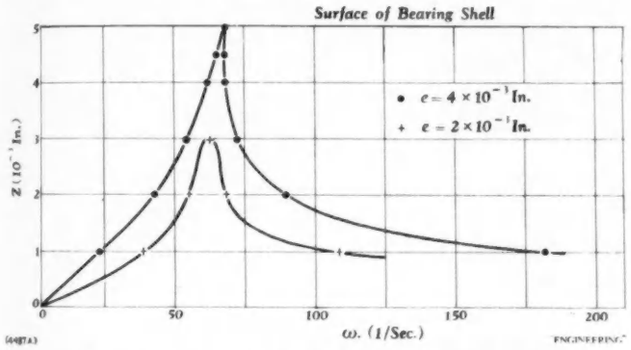


Fig. 1 Frequency response curves for a flexible rotor.

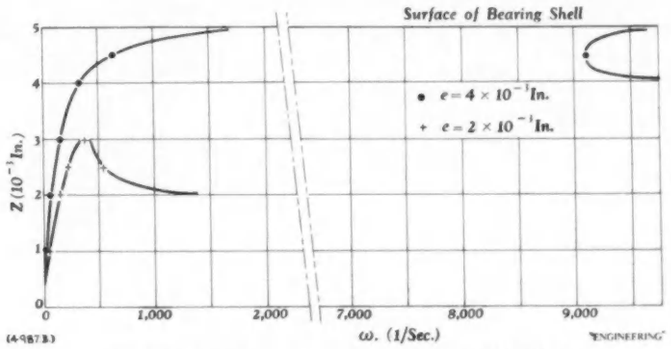


Fig. 2 Frequency response curves for a rigid rotor.

WARMING-UP STRESSES IN THICK HOLLOW CYLINDERS

*By M. J. Hillier**

When an infinitely long thick hollow cylinder, lagged at the outer surface, is heated at the inner radius at a constant rate θ' °F. per hour, a temperature gradient and its associated elastic thermal stress are set up across the cylinder wall. The methods of obtaining the temperature and stress distributions are reported widely in the literature and result in an infinite series solution in the time and radial co-ordinate variables. Considerable simplification of the numerical work may be obtained by considering the cylinder as a flat plate restrained from bending. The calculations to be described refer to the accuracy of this approximation, both for the cylinder lagged at the outer radius and for the cylinder heated linearly with time at both radii.

The axial and circumferential stresses take their largest value at the heated surface but may attain their greatest tensile value in the heated cylinder at the lagged surface, or alternatively at some point roughly midway between two equally heated surfaces. The stress at any point in the cylinder wall is expressed most conveniently as the dimensionless factor

$$\Sigma = \frac{\sigma\,(1 - \nu)\,K}{\theta'\,E\,\alpha\,(b - a)^2}$$

a function in turn of the dimensionless time $Kt\,(b/a - 1)^2/(b - a)^2$ where—

a, b are the inner and outer radii in ft; c is the specific heat of cylinder metal, B.T.U. per lb; E is the elastic modulus, lb per sq. in.; K the thermal diffusivity, k/c; k the thermal conductivity, B.T.U. per ft hour °F.; t the time, hours; α the coefficient of linear expansion, °F.$^{-1}$; θ' the time rate of heating, °F. per hour; σ the stress, lb per sq. in.; ρ the density of cylinder, lb per cu. ft; and ν is Poisson's ratio.

By plotting Σ against dimensionless time, using the cylinder thickness as parameter, an immediate comparison of the solutions for different radius ratio b/a and the same thickness may be obtained. For the cylinder lagged at the outer surface the flat plate approximation underestimates the peak stress in a cylinder of radius ratio 1·5 by 17·8 per cent. This peak stress occurs at a theoretically infinite time when the stress tends asymptotically to a constant steady-state value. On the other hand, for the cylinder heated uniformly at both surfaces, the maximum stress in the steady-state condition is relatively insensitive to the ratio b/a for a given thickness.

Calculations were also made for the case of a flat plate with a linearly heated fluid at one or both surfaces. The surface film resistance to heat transfer from fluid to plate affords protection to the plate insofar as it tends to delay the attainment of the maximum steady-state stress. If the heating period is sufficiently long, however, the same maximum stress is attained as for the plate whose surface is subject to a linear heating.

The maximum stress in the flat plate is given by the following expressions

$\Sigma = 1/6$ at the lagged surface.
$= -1/3$ at the heated surface.

The stress is tensile at the lagged surface, compressive at the heated surface (θ' positive). An approximation for the thick cylinder is given by multiplying the above factor by $(1 + 0{\cdot}144\ b/a)$, for $1 \leqslant b/a \leqslant 1{\cdot}5$. The radius ratio of 1·5 probably represents an upper limit for most practical cylinders used for pressure vessels for example. For the flat plate heated at both surfaces the above factors should be divided by 4. The correction for the cylinder is negligible.

Photocopies of the full paper, of which the above is a digest, are obtainable from the Publisher, ENGINEERING, 36 *Bedford-street, Strand, London, W.C.2. Price 25s. each, post free.*

* Rolls-Royce Limited.

Continuing **Design**

RAILWAY COACHES WITH LOAD-CARRYING BODIES

The new Metro-Cammell electric railway coaches that have entered service on the Reef System of South African Railways are unconventional in construction, being based upon the " integral tubular anti-telescopic " principle. A total of 349 coaches have been ordered by South African Railways from Metropolitan-Cammell Carriage and Wagon Company, Limited, Saltley, Birmingham, 105 are motor coaches, as shown in Fig. 1, and 244 are trailer coaches.

An interior view of a trailer coach shell is shown in Fig. 2. The whole body shell is considered as a rectangular tube with rounded corners, stiffened at intervals in its length by lateral rings formed by the crossbars, body-side pillars and carlines. The lateral rings are maintained in position by continuous longitudinal stiffening members such as cantrails, body-side rails, purlins and solebars. All these members are welded at the joins with other members and also to the outer skin, the whole forming a self-supporting and load-carrying body shell. The design aim has been to give lightness to the trailer cars, commensurate with adequate strength, and to carry the extremely heavy peak loads specified, together with the 200 ton end loading (Fig. 3). A trailer coach shell weighing just under 10 tons will support a loading of over 33 tons. A general description of the calculation methods is given in the Appendix, and weight-breakdown diagrams are shown in Fig. 4.

The underframes of the trailer coaches are built up from folded or drawn section for the solebars and crossbars, $\frac{5}{16}$ in. and $\frac{1}{8}$ in. thick, respectively, with a strong longitudinal troughing, 16 s.w.g., below the crossbars which is stitch-welded to the solebars. The crossbars run continuously from solebar to solebar; conventional longitudinals are not used. A cross beam has been added between the bolster and the headstock to deal with the buffing loads from the end longitude and to distribute these loads between solebar and bolster, and thence to the troughing which is the main member dealing with buffing loads.

The headstocks are channel sections made from $\frac{3}{16}$ in. rolled plate. A large over-rider casting has been secured to the headstock in the centre in order to prevent the couplers from separating vertically in the event of a collision, thus minimising the risk of telescoping.

The body-sides are built up from drawn sections, which make up the main framing members and to which 14 s.w.g. panels are spot-welded. The body pillars, cantrail and cribrails are in 12 s.w.g. while the longitudinal rails are 14 s.w.g. All the frame members, both vertical and horizontal, are continuous, and the body pillars are notched as required to pass the longitudinal rails. The panels are pressed for window openings and doorways, and are automatically seam-welded before being spot-welded to the framing. Shallow " top-hat " sections are used for the horizontal rails and modified channels for the pillars.

The principle of roof construction is similar to that of the body-side; the carlines, which are individual pressings from cantrail to cantrail, are notched to allow the purlins, which are V-sections, to be continuous from one end of the roof to the other. The frame members are welded to each other and stitch-welded to the roof sheets. The end framing is somewhat more rigidly constructed because of the possibility of collision, although folded and drawn sections are still used in conjunction with 14 s.w.g. panels.

As far as possible, structural conditions which would be favourable to corrosion have been avoided. In addition, the inside of the body shell is given coats of bitumastic paint before sprayed asbestos is applied. All window pockets are lined with zinc trays with direct outlet tubes in order to deal adequately with the heavy rainfall which is experienced at times in South Africa. To assist in corrosion resistance, Cor-ten steel has been used for all the structural components.

The motor coaches are very similar in design to the trailer coaches above the solebars; below this level the underframe has been strengthened to carry the many heavy items of electrical equipment.

The trains are designed to run from a 3,000 volt direct-current supply from overhead wires and can be operated from the cab at either end of the train. A typical eight-coach train consists of six trailer coaches with a motor coach at each end, the main dimensions of the vehicles being as follows: length over body end panels, 60 ft $3\frac{5}{8}$ in.; width over body panels, 9 ft 3in.; centres of bogies (motor coaches), 41 ft; bogie wheelbase (motor coaches), 9 ft; centres of bogies (trailer coaches), 44 ft 6 in.; bogie wheelbase (trailer coaches), 6 ft 9 in.; track gauge, 3 ft 6 in.

Of the 105 motor coaches, 60 have first-class accommodation (48 seats), ten have a guard's and baggage compartment with first class " reserved " for non-Europeans (40 seats, as depicted in Fig. 1), and 35 have a guard's and baggage compartment with third class accommodation (36 seats). The 244 trailer coaches are sub-divided into 178 first class, 33 first class " reserved " (both with 62 seats) and 33 third class (60 seats). The first-class seats are upholstered double seats either side of a central gangway, whereas the third-class seats are of slatted wooden construction arranged longitudinally along the coach walls, leaving ample standing room in the centre.

Interesting points in the interior equipment of the coaches are the provision of a photo-electric cell in each car for automatically switching on the lights when the light inside the car falls

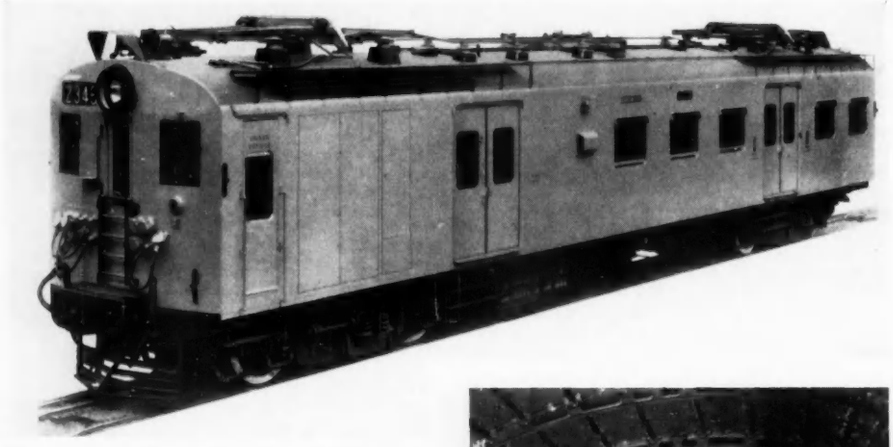


Fig. 1 First-class motor coach with baggage space and accommodation for 40 passengers, built by Metro-Cammell for South African Railways.

Fig. 2 (above) Interior view of a trailer coach, showing the body shell structure.

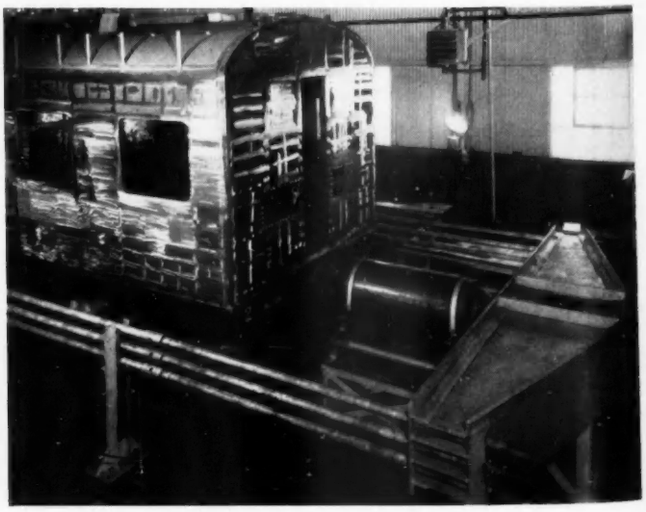


Fig. 3 (right) Applying a 200 ton test load longitudinally.

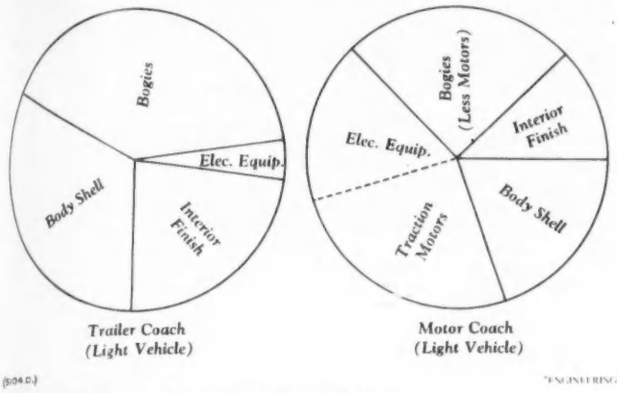


Fig. 4 (left) Weight breakdown.

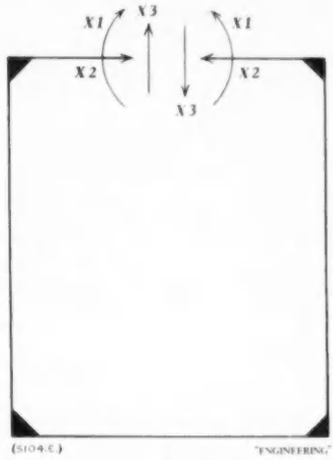


Fig. 5 (right) Consideration of forces in a rectangular frame.

below a predetermined level; the use of Hera equalisers to balance the window weight so that the window can be left in any desired position without the use of semi-positive stops; and easily-removable complete self-contained window assemblies—including window, equaliser, guides, blind and interior-finish panel below the waist—to facilitate maintenance.

Metro-Cammell are making 70 of the motor coaches and 123 trailer coaches at their Midland Works, Washwood Heath. The remainder have been sub-contracted to the Birmingham Railway Carriage and Wagon Company, Limited, Smethwick. The sub-contractor for the main electrical items is the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester.

Appendix: Method of Stress Analysis

Most important among various loading conditions considered were the following: (*a*) Vertically applied loads due to structure, equipment and passenger weights, representing in one case a load of 33 tons. (*b*) Horizontal loading due to traction, braking and buffing forces. In this load category all coaches had to be proved capable of withstanding a minimum of 200 tons, applied at the centre coupling, without damage. At end loadings above this figure it had to be arranged that damage should first occur in the areas between bolster and headstock before any damage occurred between bolsters.

In the calculations of the basic structure all interior finish and furnishings were neglected, and the steel shell was represented as a Vierendeel or rectangular-framed truss simply supported at two points coinciding with the centre pivots.

In the horizontal plane, the unity of the main structure is impaired by the openings required for doors and windows, and deflections under vertical loads take place about two horizontal neutral axes. One of these is located above windows and doors within the group of members formed by the cantrails, purlins, upper body-side sheets and roof sheets; the other is situated within the lower structure below doors and windows. Vertical connections between these two main groups are formed by the pillar structures and quarter panels whose neutral axes complete the representation of the structure as a series of rectangular frames, which can be solved by mathematical analysis.

The calculations were based on the theory that the external work done by the loads deflecting the structure would equal the sum of the internal work stored in all the members. As a first step, one member in each rectangular frame was assumed to be severed at its mid-point and sufficient forces introduced at that point to represent completely the function of the continuous member (Fig. 5). This involved three forces X_1, X_2 and X_3 capable of simulating any condition of bending, shear or direct force in the member.

The external loading was then applied to the structure, and the resulting deflections at each cut or break were equated to the component deflections induced at the same cut by unit loads applied in the position and direction of the unknown X forces. Thus a series of simultaneous equations was evolved, the unknown X forces representing the magnitude of forces introduced into the primary structure. Thus:

$$X_a \delta_{a\,a} + X_b \delta_{a\,b} + X_c \delta_{a\,c} \ldots = -\delta_{a\,o} \quad (1)$$

where $\delta_{a\,o}$ is the deflection in direction of X_a at a point where X_a acts when all external loads are applied to the structure; $\delta_{a\,a}$ is the deflection in direction of X_a at a point where X_a acts when unit load is applied at X_a; and $\delta_{a\,b}$ is the deflection in direction of X_a at a point where X_a acts when unit load is applied at X_b, and so on.

The values of δ were calculated from the following standard equation of work:

$$\delta_{a\,b} = \Sigma\left[\int_o^l M_a M_b \frac{ds}{EI} + \int_o^l P_a P_b \frac{ds}{EA} + \int_o^l Q_a Q_b \frac{ds}{GA}\right] \quad (2)$$

where M_a, P_a and Q_a are bending moment, direct load and shear force, respectively, in length ds of any member of the frame caused by the application of unit force in position of X_a; and M_b, P_b and Q_b are similar quantities due to the application of unit force in the position of X_b. The summation embraces all members affected by both M_a and M_b.

The two latter terms in equation (2), expressing deflection due to shear forces and direct forces, have a minor influence and can be eliminated.

Therefore

$$\delta_{a\,b} = \Sigma \int_o^l M_a M_b \frac{ds}{EI} \quad (3)$$

It will thus be seen that three unknown forces resulted from each bay of the body-side structure, involving a somewhat lengthy series of equations; these were successfully solved by recourse to the Gauss tabular method.

Having obtained the true values of all X forces, they were applied to their respective positions and the internal distribution of bending moments, shear forces and direct loads was plotted. The calculation of stresses then became a straightforward matter using standard formulae.

Once the internal bending moment distribution was known it was also possible to calculate the deflection of any point quite simply by applying unit load in the direction and position at which the information was required. The bending moment induced by the unit load was then integrated with the moment due to the loading conditions being considered, and the following information was obtained:

$$\Delta = \Sigma \int_o^l M_u M \frac{ds}{EI}$$

where $-M_u$ is bending moment due to the application of unit load at point being considered, and $-M$ is bending moment in any member due to loading condition under consideration.

The results obtained from this method of analysis proved a good guide to the behaviour of the first coach under actual strain-gauge testing.

RUNNING-IN SLEEVE BEARINGS

Factors affecting the performances of sleeve bearings include the materials of both bearing and journal, the lubricant, the length/diameter ratio, and the diametral clearance ratio; the surface finish, taper and ovality of both journal and bearing; and the conditions of operation, by altering the rate of heat dissipation from the bearing. Some of these factors have been studied by the Australian Commonwealth Scientific and Industrial Research Organisation, Division of Turbophysics, and the method of testing and the results have been described recently in a paper to the Institution of Mechanical Engineers: "Sleeve Bearings. Part I: Development of a Testing Machine," by Mr. A. J. Davis, senior research officer with the C.S.I.R.O., and Mr. T. V. Krok, Tecnico Limited (Sydney), formerly with the C.S.I.R.O.; and Part II: "Running-in Characteristics," by Mr. A. J. Davis.

Using a test rig specially developed for measuring the relevant parameters in the transition region between full fluid and boundary lubrication, the investigation aimed at determining the ultimate performance obtainable from typical journal bearings at low values of the duty parameter ZN/p, which determines the coefficient of friction f. (Z is the lubricant viscosity, N the shaft speed, and p the pressure on the projected bearing area). Two types of bearing metal were tested—tin-base Babbitt, and cadmium silver—on standard journals in a hardened and tempered manganese-nickel-chromium steel, with various types of surface finish—ground to 12-15 micro-inches, hand lapped to 2-4 micro-inches, or superfinished to 2-3 micro-inches.

From the test results, Mr. Davis concludes that tin Babbitt bearings run-in more rapidly than the cadmium-silver bearings, and that they show a somewhat lower ultimate value of the duty parameter for minimum friction. The main effect of running-in is to produce smoother surfaces which will operate with oil films of lower thickness.

Surface finish of the journal and bearing is the predominant factor under conditions of thin-film lubrication. Super-finishing of the journal increases the load-carrying capacity, but the finish of the bearing is less critical provided that some running-in under light load is possible before extreme conditions are applied. The performance of a uni-directionally loaded bearing appears to be improved by small local changes in bearing curvature which occur during running-in.

Coating the bearing and journal with molybdenum disulphide before assembly is advantageous during running-in, particularly in the early stages, and may facilitate the formation of smoother bearing surfaces.

AMERICAN FOUNDRY PRACTICE

Two new sections have been formed within the American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Illinois, U.S.A. Existing divisions of the Society deal with grey iron, malleable iron and other subjects, and the new divisions will be concerned with ductile iron and with die castings and permanent moulds. It is intended that committees to deal with melting methods, basic metallurgy, gates and risers, welding, quality control, and heat treating will be elected under the aegis of the ductile-iron division. In the die-casting and permanent-mould division, the committees to be elected will be concerned with executive matters, programmes and papers, research, alloys, and die and mould materials.

Book Reviews

THE DAWN OF AUTOMATION

A History of Technology. Volume III: From the Renaissance to the Industrial Revolution *c.*1500-*c.*1750. Edited by CHARLES SINGER, E. J. HOLMYARD, A. R. HALL and TREVOR I. WILLIAMS, assisted by Y. PEEL and J. R. PETTY. *Oxford University Press, Amen House, Warwick-square, London, E.C.*4. (168*s.*)

With the third volume of this magnificent work, we enter at the birth of modern science and leave with the foundation of the industrial revolution. Nevertheless the period it covers was still one in which technological development owed little to scientific knowledge, although in some fields, such as instrument making, it was stimulated by the needs of the scientists. Instead of industry benefiting from science during these years, science began to look to the artifacts and processes of industry as objects worthy of organised study.

In classical times, when the advancement of knowledge depended on speculation rather than on observation, it was considered beneath the dignity of a scientific philosopher to become involved in the work of the craftsman or artisan or to conduct any inquiries which might have practical ends. The Middle Ages were a period of dogmatism and theological disputation but after the Reformation the scientific spirit underwent the glorious revival on which the achievements of modern science have been built. It is interesting, therefore, to read that the creators of that revival strongly advocated that the scientist should observe what the craftsman did and should endeavour to find the natural laws which governed his empirical performances.

Francis Bacon, holding that learning was too remote from everyday affairs, called for the collection of abstracts and "patterns" of experiments and their study by scientists with a view to discovering general principles on which further advances could be made. His views were adopted by men such as Robert Boyle, William Petty and Robert Hooke in this country, as well as others in Germany, France and Sweden. Confidence grew in the experimental method and technology began to benefit from it during the second half of the Seventeenth Century. It was not, however, until the end of the period covered by this volume that science began to repay its debt to technology and then chiefly in the chemical industries. Since that time the balance of the account has swung in a direction that the early craftsmen-engineers of the industrial revolution could never possibly have foreseen.

Though still largely empirical, technology in the Sixteenth and Seventeenth Centuries made rapid strides, not so much in radical new inventions as in improvements in technique. This was in all probability due to a single technological development, that of printing and the associated arts of drawing and engraving. Descriptions of machines and processes multiplied and led to their wider application and more intensive study and improvement. It is surprising how old most tools and many mechanical devices are. The hand tools used in many woodworking crafts have hardly changed over centuries. The principle of the plunger pump, of the screw, of the clock escapement, of the water wheel, are very ancient. In later times the turbine was already in use in the Seventeenth Century in the form of a fan in the kitchen chimney to turn the spit; and the principle of the thermostat was known by the Sixteenth Century and had been used in an egg incubator. This was an early example of the "feedback" mechanism and the punched card of the pattern loom was another early precursor of automatic control.

It was the improvement in some of these mechanisms which made them worthy of study by scientists looking for the principles of their operation. For instance, the improvement in pumps led to the scientific analysis of the vacuum by Gelder, Torricelli and Pascal. On the other hand, the increasing need for accuracy by the astronomers led to the improvement in telescopes and their mechanisms by the makers of instruments. Previously their instruments had been made by the scientists themselves.

The unsolved mystery of this history is why these developments should have taken place in Europe rather than in the Eastern civilisations in whose technologies, including that of printing, many of them had their origins. The usual explanation, that it was due to the less tradition-bound society which developed in Europe after the Reformation, only poses the question as to whether there were geographical or other causes of the break with tradition itself; whether, for instance, small nations with long sea coasts had advantages over peoples set in large land masses. For this was the period also of the growth of military superiority based on advances in shipbuilding and navigation, and of the long period, just ended, of European control of the Far East. Unfortunately, the editors, by self-denying ordinance, do no more than raise these interesting speculations in a brief chapter at the end by Dr. A. R. Hall.

The remaining chapters contain little economic or sociological matter, but are chiefly confined to fascinating descriptions illustrated by many interesting contemporary drawings. A brief but interesting chapter tells the story not only of the methods of mining coal but also the effect of its long delayed use on many other technological developments which contributed to the industrial revolution. Other chapters cover activities as widely different as food and drink, glass manufacture, town planning, machines and mechanisms, cartography, survey and navigation, the calendar, and invention in the chemical industries. In view of the mass of material here presented it is, perhaps, unfair to mention omissions; but two come to mind: the making of furniture and the making of musical instruments.

One of the main differences between the older and newer technologies is that, whereas—in the old—art and technique were inseparable, for instance in Chinese porcelain or in fine fabrics—in the new—advances were usually in the direction of standardisation and repetition of a good article in large numbers. In the Middle Ages refined techniques were only used for making goods for the wealthy; the mass of people using nothing but the crudest products. In the Seventeenth Century the products of Europe were inferior to those of the East, but its higher level of technical proficiency led to an increasing technological homogeneity based on the cheaper production of goods.

That technological progress must ultimately depend on the advance of science was contemplated by scientists and philosophers at least by the Seventeenth Century. Bacon, in his *New Atlantis*, foretold not only metallurgical and chemical discoveries but artificial light, mechanical power, aeroplanes and submarines. This was more than the prophecies of earlier writers, dreaming of the apparently impossible. It was the faith of the natural scientist that all will be disclosed to the patient investigator using the methods of his craft and confident that what is known can be applied. We, who live under the shadow of this belief, no more than they who started us on the journey, can see the end of the road.

AID TO WORK STUDY

Work Sampling. By RALPH M. BARNES. Second edition. *John Wiley and Sons Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y.* (8 dols.); and *Chapman and Hall Limited*, 37 *Essex-street, London, W.C.*2. (64*s.*)

This is the second book on work sampling to appear during the last three months from the United States. Work sampling is a modern term for a technique termed "snap reading," or "ratio delay," which originated with Mr. L. H. C. Tippett and which is being used increasingly in work study, especially in America. Professor Barnes has gone farther than certain other authors in that he has rightly included time-lapse photography within "work sampling" but as this is barely mentioned in the book it would seem that he, with others, implies the "ratio delay" technique when discussing "work sampling." This seems to be an unfortunate use of the term "work sampling" as it is too restrictive.

The book is set out in three main parts covering, firstly, the fundamental statistical concepts involved and the procedure of making a ratio delay study; secondly, case histories of the technique applied in various fields; and in the third part, background information on the technique intended to be of particular use to college students, including a reprint of Tippett's original paper which is now difficult to obtain. The book includes many reprints of papers by Professor Barnes and his associates. This makes the book difficult to read easily, as the styles adopted in the separate papers are not suited to continuous reading, although they may be suited for specific reference to certain points—but this is not the general purpose of such a book. The reviewer found particular difficulty in deciding the level of readership for which the book is intended. Many pages are devoted to outlining simple statistical concepts such as the Gaussian curve, control charts and the use of random numbers. On the other hand, in Tippett's paper analysis of variance is used, but the reason for the use of this statistical technique is unexplained. Since a common fault of technicians using Tippett's technique is neglect of examination of the sources of variance, a useful opportunity has been lost to explain a fundamental point arising in the applied technique. As the ratio delay technique depends upon the validity of applying binomial distribution (and not Gaussian) theory, it is unfortunate for readers not experienced in statistics that no exposition has been made of the difference between binomial and Gaussian distributions, which can be important in this instance. The proof reading is at fault in this reprint: x^3 is used in several places instead of χ^2.

The case histories are very helpful as the general reader is shown the wide field of application so that he can, by extension, see the opportunity of making applications to suit his own problems. This practice of giving applications in the form of case histories is now common in the industrial engineering field and is very useful for practitioners.

A paper is reprinted in which is examined the validity of applying the ratio delay technique. In this the "normalcy" of a study was examined by χ^2 and then, as a consequence, a criterion derived from Tchebycheff's Inequality was developed. This whets the appetite because the technician would like to ask questions such as "Why expect a 'normal' distribution rather than a log-normal distribution, which is probably just as common in industrial work?" Unfortunately such points are not examined—a fault which derives from reprinting original papers without adequate editing.

The criticisms made above obviously depend upon the level of reviewing adopted and this is probably fixed unconsciously by respect for Professor Barnes' general work. For the reader

who is prepared to be critical much benefit will accrue from reading the book. A very useful bibliography is given which includes modern British contributions and therefore the reader who wishes to go further is aided substantially.

NEW BOOKS

Metallurgical Aspects of the Control of Quality in Non-Ferrous Castings. Institute of Metals Monograph and Report Series No. 22. *The Institute of Metals*, 17 *Belgrave-square, London, S.W.*1. (35*s.*)

The eight papers contained in a symposium on the control of quality in non-ferrous metal castings, held in London on the occasion of the annual general meeting of the Institute of Metals on May 1, 1957, together with the discussion to which they gave rise, have now been published as Monograph No. 12 by the Institute. The papers, which cover aluminium-alloy, copper-base, magnesium-base, nickel-alloy, and other non-ferrous metal castings, have been submitted by authors employed by the British Non-Ferrous Metals Research Association, the Northern Aluminium Co. Ltd., the Birmingham Aluminium Casting (1903) Co. Ltd., J. Stone & Co. (Charlton), Ltd., Magnesium Elektron Ltd., the Mond Nickel Co. Ltd. and Hoover Ltd.

King's College London Engineering Society, 1847-1957. By W. O. SKEAT. *The Registrar, King's College, Strand, London, W.C.*2. (12*s.* 6*d.*)

As is shown by the title of this attractive cloth-bound volume, King's College London Engineering Society celebrated its centenary some ten years ago. In several respects unique, the Society claims to be the oldest of its kind in the country and, possibly, in the world. It has, as Dr. Peter S. Noble, the Principal of King's College, states in his foreword, an unusual, but very happy and fruitful, constitution whereby its officers and committee are changed every term; and it has enjoyed a much closer association with its faculty and college than is customary. During its existence, the Society has seen great changes, not merely in engineering education and practice, but in university education as a whole and, indeed, in the national life. Mr. W. O. Skeat, the author, has provided a very readable account of the Society's vicissitudes and achievements during this long and momentous period. The illustrations include a number of photographs, some of which, centring around Reggie, the College mascot, will surely arouse memories in King's men of all faculties—and beyond!

The Life and Work of Frederick Winslow Taylor. By LYNDALL F. URWICK. *Urwick, Orr and Partners Limited*, 29 *Hertford-street, London, W.*1. (2*s.* 6*d.*)

Scientific management has earned an established place for itself in the scheme of things and much more will be heard of its principles in the years to come. The present paper was delivered to the eleventh International Management Congress in Paris in June last, and commemorates the centenary of the birth of "F. W. Taylor, known as the Father of Scientific Management." It shows that Taylor was a man of exceptional vigour who played an exacting and exciting part in the business affairs of the United States. Born at Germantown, Pennsylvania, in 1856, he served an apprenticeship as a machinist and turner, and, because business was bad, took a job as labourer at the Midvale Steel Works in 1878. From this beginning, he had risen to the position of chief engineer by the time that he left the Midvale Works, 12 years later, to become general manager of the Manufacturing Investment Company. One of his dicta was that both sides of industry should take their eyes off the division of the surplus as the all-important matter, and *together* turn their attention towards increasing the size of the surplus.

Dangerous Properties of Industrial Materials. By N. IRVING SAX, assisted by LEONARD J. GOLDWATER, WILLIAM B. HARRIS, JOHN H. HARLEY, JOSEPH J. FITZGERALD and MILTON S. DUNN. *Reinhold Publishing Corporation*, 430 *Park-avenue, New York* 22, *N.Y., U.S.A.* (22.50 dols.); and *Chapman and Hall Limited*, 37 *Essex-street, London W.C.*2. (180*s.*)

The main purpose of this truly monumental volume of 1,467 pages is to extend the scope and improve upon the usefulness of a previous work in this field by Mr. N. I. Sax, entitled *Handbook of Dangerous Materials*. It furnishes engineers, chemists and also non-technical personnel with encyclopaedic data on the hazards involved in the manufacture, use, handling, storage or conveyance of general chemicals and industrial materials, in various forms. The precautions to be taken and the methods of fighting a fire or of meeting other eventualities are given.

Proceedings of the Fifth Midwestern Conference on Fluid Mechanics held at the University of Michigan, April 1 and 2, 1957. Published for The Engineering Research Institute by *The University of Michigan Press, Ann Arbor, Michigan, U.S.A.* (8 dols.)

Among the topics dealt with in the 26 papers presented at the conference are flow through tubes and in boundary layers; flow about bodies at subsonic, supersonic, and hypersonic speeds; and shock waves. The authors, who are associated with universities in the United States and in other countries or who are connected with research and development organisations and laboratories, are considered to be authorities in their own particular field.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Universal Tool Head. BURTON, GRIFFITHS & CO. LTD., Montgomery-street, Birmingham, 11. Universal tool head, made by the Newall Engineering Co. Ltd.; Burton Griffiths are the sole agents for Great Britain. The tool head has a taper shank for the machine spindle, and an adjustable tool holder, with a scale having English or Metric graduations. Boring, counter-boring, facing, undercutting, trepanning and back-facing can be carried out on various types of machine. Illustrated leaflet.

Indexing Diamond Dressing Tool. UNIVERSAL DIAMOND CO. LTD., 15 Rodmarton-mews, Baker-street, London, W.1. "Unidex" position-indicating diamond dresser for grinding wheels, which enables the tool to be indexed through 90 deg. as soon as the diamond cutting edge is worn. Accurate indexing gives increased tool life. Illustrated leaflet explaining the principle of operation involved.

Bar and Tube Straightening. FRANK WHITELEGG, LTD., 304 High-street, Sutton, Surrey. Three machines made by Th. Calow & Co., Bielefeld, Germany. One machine, with a capacity range from $\frac{3}{8}$ in. to 4 in. diameter, is for straightening tubes only, one is for bars only, from $\frac{3}{8}$ in. to $1\frac{5}{16}$ in., and one can be used for straightening rough-rolled bars or for straightening and polishing bright material, within the size range 1 in. to $3\frac{1}{8}$ in. diameter. Three illustrated leaflets.

Precision Taper Roller Bearings. GAMET PRODUCTS, LTD., Hythe, Colchester. Single- and double-row taper roller bearings, with plain or flanged outer rings, to specially fine tolerances for machine tool and other precision work. Leaflet giving general details and information on tolerances, and four data sheets with dimensions of a range in English and Metric sizes from 35 to 210 mm.

Superfinished Reamers. BURTON, GRIFFITHS & CO. LTD., Montgomery-street, Birmingham, 11. Details of B.S.A. "Superland" reamers, for hand and machine, all of which, down to $\frac{1}{4}$ in. diameter, are now superfinished on the lands to a standard of 2 micro-inches. Illustrated brochure.

Industrial Refrigerators. U.D. ENGINEERING CO. LTD., Cumberland-avenue, Park Royal, London, N.W.10. Commercial and industrial refrigeration plant of all sizes—compressors, evaporators and coolers. Illustrated booklet shows applications.

Grit Washing and Collecting. LINK-BELT CO. Prudential Plaza, Chicago, 1, Illinois, U.S.A. Design data on grit washing and settling tanks, collectors and screens Booklet No. 2571.

Power Plant. THE BRUSH GROUP LTD., Duke's Court, Duke-street, St. James's, London, S.W.1. Outline of the firms composing the group, their activities and products. Pocket size booklet.

On the Shelf

By Frank H. Smith

An Electronics Group of Aslib has been formed. Mr. N. E. C. Isotta, who belongs to the Ministry of Supply (T.I.L.)*, has been the honorary secretary of the guiding committee and it is intended that the Group should serve both users and manufacturers. The decision to form a Group rather than a section of the existing Engineering Group was reached after it was pointed out that users would include other branches of science (such as domestic science and medicine) that had no connection at all with engineering. Mr. J. E. Wright, librarian, Institution of Electrical Engineers, has consented to act, temporarily, as chairman of the Committee.

The British Standards Institution, with its January number, *B.S.I. News*, has caught the fever and "gone pictorial." The paper employed does not take very kindly to photographic reproduction and, frankly, I do not like it. The Institution proclaims a new committee on classroom chalk. Casting my mind back over 30 years for suggestions I should like to think that steps will at last be taken to ensure that the diameter of a stick of chalk is too great to fit into a classroom inkwell. Three pages of the *News* are given over to a review of the position with regard to the "International Unification of Engineering Drawing Practice" between the A.B.C. (America, Britain, Canada) countries.

An abstract, in the Engineering Institute of Canada's *Engineering Journal* of January, of an article in *Metal Progress* quotes some disquieting figures in connection with "What's in the Literature (the Importance of Documentation)." In 1956, the *Engineering Index* prepared 27000 abstracts in all fields of engineering. The "free world" prepares, on the average year, about 300000 abstracts while the Soviet Union does about 400000. In 1952, the library of the United States Congress received nearly 40000 journals representing about $1\frac{1}{2}$ million individual issues. No later figure is given but it is a known fact that literature increases appreciably year by year and to-day's figures must be appalling. One gets tired of saying "Where will it end?" It won't, and what is distressing about it all is that nothing can be done about it.

There may be people who, like me, try to keep a note of the various medals and awards and the bodies who present them. The Engineering Institute of Canada has instituted the Robert W. Angus Medal for the best paper each year on a mechanical-engineering subject. Professor Angus, now in his 84th year, is emeritus professor of mechanical engineering at the University of Toronto.

The chief aeronautical research body in France is L'Office National d'Etudes et de Recherches Aéronautiques, 29 Avenue de la division Leclerc, Chatillon-sous-Bagneux, and they have just issued a useful *Catalogue des Publications* covering the years from January, 1951, to January 1957. This is an unusual bibliography in that each page is divided into two columns—French and English side-by-side.

The Institution of Civil Engineers has drawn attention to the "Railway Engineering Abstracts" compiled by themselves and the British Transport Commission. They rightly point out that, as in other fields, railway engineering is constantly improving, taking advantage of new techniques and discoveries and advancing in its own way as rapidly as the newer sciences. Railway Engineers have as great a need as others for awareness of what is "going on" but they cannot hope to keep abreast of the mass of literature that is published and it is here that the "Abstracts" can help. They are free to members of the Institution and can be purchased by others and *that* is where the circular falls down. No price is given.

* Technical Information and Library Services.

Production

FACTORY IN THE COUNTRY

Factories far from traditional manufacturing areas were the product of a war-time need for dispersal. After the war, with this need no longer so great, the idea of building factories away from the industrial centres was sometimes opposed for a variety of reasons. It was suggested particularly that labour, freed from the controls imposed during the national emergency, would be difficult to obtain, and that the siting of a factory in a rural area would be detrimental to the amenities of the district. How wrong both these assertions could be has been demonstrated by the new factory built for Standard Telephones and Cables, Limited, in the West Country.

Paignton, the site chosen, is a well-known holiday resort in an area of considerable scenic beauty; but the factory has been so designed as to harmonise extremely well with the local traditional styles of building, while retaining a very modern layout, convenient for production purposes. Extensive landscaping has been carried out to improve the external appearance of the factory, and everything possible has been done to provide good working and welfare conditions as well as a pleasant appearance. A feature which contributes to both amenity and recreational facilities is the swimming pool which adjoins the laboratory wing. The pool is, in fact, a heat exchanger for the closed-circuit distilled-water cooling system used in testing water-cooled valves, and is a good example of how the utilitarian can be made attractive.

The origin of the Paignton factory was in a war-time move of the telecommunications valve manufacturing activities of Standard Telephones and Cables from Woolwich to temporary premises at Ilminster, in Somerset. Soon after the end of the war it was decided, that as the Ilminster premises were unsuitable for the manufacture of the more intricate valves coming into use, the Valve Division should be moved. Various sites were considered in the West Country, this area being suggested by the Government, to avoid over-concentration of valve manufacture in London, and eventually a site of 46 acres was acquired in Paignton. This town had a seasonal employment problem, there being a large pool of labour available especially in winter. As regards possible interference with the amenities of what was, and still remains, a popular holiday resort, radio valve manufacture is not a process which produces dust, dirt, smoke or noise; quite the reverse, in fact, extreme cleanliness is essential in valve assembly.

The design of the factory, essentially a single-storey building with a floor area of 150000 sq. ft, was based on a central power house and services building, and provision was made for expansion of manufacturing facilities eventually to cover about 400000 sq. ft. Some development of the buildings has already taken place, the present area being nearly 170000 sq. ft, and further extensions are in hand.

PREPARING FOR THE MOVE

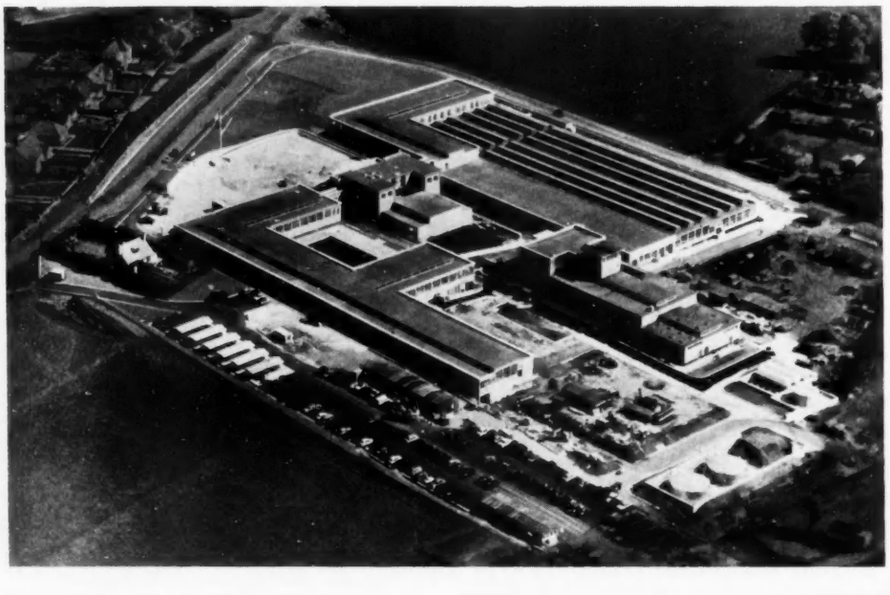
A start was made on the site of the factory in October, 1954, and plans were made for the removal of manufacturing piecemeal from Ilminster as buildings became available. Some manufacturing was transferred in September, 1956, and the occupation of the valve production unit and valve laboratories started in March, 1957.

While building was in progress, premises were rented in Paignton for training local labour and by January, 1955, some 150 workers were undergoing instruction. Meanwhile, preparations had to be made for housing the 400 key personnel who were to be transferred from Ilminster, and as 300 of these workers required houses, arrangements were made with the Local Authority for building 100, and a housing association was formed to erect the remaining 200. Local recruitment and training and the movement of Ilminster workers enabled the factory to be staffed as required, and the transfer of production proceeded smoothly. To-day, the labour force is about 1100, and more workers are being taken on.

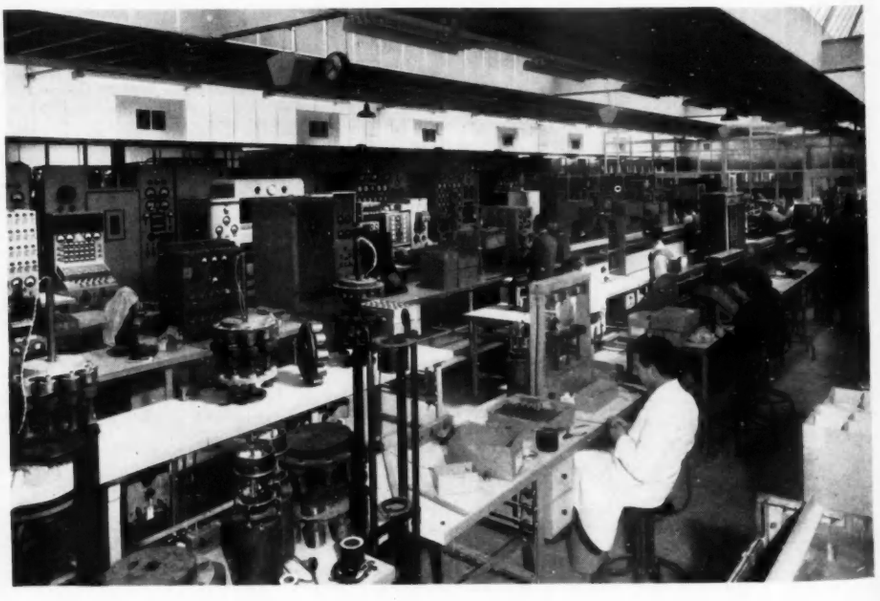
A particularly compact and simple layout allows for every process of valve research, development and manufacture to be carried out within the factory walls. The main entrance communicates with three of the principal buildings. On the left is the works and administration block, and on the right the laboratory block, the two being connected by a covered corridor. Integral with the main entrance is the reception area and conference room, and behind it, centrally placed with respect to the whole location, a restaurant block. In the administration block there are managerial, planning, engineering and drawing offices, together with personnel and surgery units, all of which communicate readily with the works.

The laboratory wing is self-contained, with its development section, model shop, and laboratories devoted to high- and low-power valves, gas tubes and micro-wave valves. A chemical, a process, and an applications laboratory are also included in this wing, together with a technical library, and a special dust-free area devoted exclusively to the production of submerged repeater valves for submarine cables. More than 34000 sq. ft are occupied by the valve laboratories.

Valve production at Paignton ranges over the whole field of telecommunications and industry, from the small conventional types as used in radio receivers, and the special long-life valves for telephone repeaters, to the large high-power water and forced-air cooled types for sound and tele-



(Above) Situated in a rural area, the Paignton valve factory of Standard Telephones and Cables is designed to give ideal employment conditions and to harmonise with the surroundings.



(Below) The main production area, like the rest of the factory, is air conditioned, and all services are taken under the floor. Along the back wall are the pumping stations, for evacuating valve tubes.

vision broadcasting. Special super-high-frequency valves, as used in radar, form an appreciable part of the total output; these are now finding additional use in super-high-frequency links for television and multi-channel telephony, as well as in aircraft navigational aids. Gas-filled valves for special electronic applications are also produced on a large scale.

Manufacture of such specialised products means that many special techniques and machines are used, some of the equipment being of the company's own design and manufacture, though orthodox machine tools and manufacturing methods also have their place in the factory. Metal spinning, for example, is employed for the production of numerous valve parts, and the machine shop and tool room are typical of good modern practice.

It is in the layout of the manufacturing area, and the provision of the essential services, many of which are not found in an ordinary engineering works, that the art and skill of the engineer and architect have been most impressively demonstrated. The production area is divided by the intersection of two longitudinal and three lateral passageways, which are formed by glazed partitions, and the processes are so arranged as to give a direct flow from the raw materials store at one end of the building to the final inspection, packing and dispatch area at the other end. Road vehicle unloading and loading facilities are provided at the receiving and dispatching points.

CENTRAL SERVICES

As mentioned previously, cleanliness is vital in valve manufacture, and the entire manufacturing area is supplied with filtered and temperature-controlled air. Specially-designed rooms are provided for processes which demand absolute cleanliness. An important feature of the production area is that it is built on steel pillars, to provide a space below the floor for all supply services. The air-conditioning plant is housed in this space, and all piping for gas, water and air, together with electric wiring, is carried in the under-floor space to a point immediately below where it is needed, and then taken up through the floor to the machines and benches. Apart from the fact that all the service piping and wiring is accessible for maintenance, its absence in the production area means that there is so much less to keep clean. A central vacuum cleaning plant is included among the equipment below the factory floor, with piped "plug-in" points at frequent intervals throughout the production area. A considerable amount of chemical processing is necessary in valve manufacture, and acid wastes are disposed of through plastic pipes taken along the under-floor space to neutralising plant.

Main services, such as heating, industrial gases and compressed air, are supplied from a service block which is in the physical centre of the site. It has been designed and equipped to deal with the factory in its fully developed form.

Three oil-fired La Mont boilers supply high-pressure hot water for space heating and for domestic services throughout the works and offices, each boiler having three burners, to give a very flexible output according to need. Nearby oil tanks have a storage capacity of 30000 gallons. Compressors in the same building supply high-pressure coal gas and air for various processes in the works, particularly for glass working. Quantities of industrial gases are needed in valve manufacture, and the service block contains an electrolytic plant for producing oxygen and hydrogen. A separate plant in an adjacent room produces nitrogen, and a group of gasholders is provided nearby for storage.

Electricity is taken from the public mains, but as there are certain processes in which continuity of supply is essential, a 500 kW Brush generator, driven by a Petter oil engine, is installed in the service block. A fully-equipped maintenance workshop and a road vehicle garage complete the service block.

The factory is now in full production, and a further 60000 sq. ft are now being developed on the site, for the production of capacitors.

Construction

PRESTRESSED BRIDGE ON THE RIVER TRENT: 275 FT SPAN

The new Clifton road bridge over the River Trent near to Nottingham contains the longest span — 275 ft — of prestressed concrete yet erected in the United Kingdom. An aerial view of the bridge from the south-west is shown in the illustration. The main bridge has been designed as two balanced cantilevers with a central suspended span of 100 ft; the cantilevers are thus each 87 ft 6 in. long. The balancing spans are 125 ft long. At the north end the deck is supported by a cellular retaining wall with wing walls of counterfort construction containing the end of the approach embankment. At the southern end a cellular abutment forms a junction support for the "tailing-down" span and the first of three 90 ft spans of a viaduct which crosses low-lying land liable to flooding. The two main piers carrying the cantilevers are solid, of reinforced concrete, and built above concrete piles. A concrete hinge has been formed between the pier cap and the bridge spans.

A 22 ft carriageway, a 9 ft cycle track and one 5 ft 6 in. footpath are provided, within an overall width of 46 ft 3 in. The design satisfies the Ministry of Transport standards for abnormal loading. There is an angle of skew to the river of 24° and the location is about 1½ miles upstream from Trent Bridge. The approach roads are laid on earth embankments having a maximum height of 30 ft. When the local trunk road programme is put in hand a duplicate bridge will be built immediately adjacent as part of a dual carriageway system.

The profile of the main bridge is composed of flat curves and the depths of the structure (underside of road surface to the soffit line) at critical points are: mid-span, 6 ft; end of suspended span, 6 ft 9 in.; at the main piers, 17 ft 8⅝ in.; and 5 ft 6 in. at the tailing-down point, a depth of construction which is maintained throughout the length of the viaduct.

Cellular construction, with 12 in. thick connecting webs and diaphragms, has been used for the cantilever members; the longitudinal webs are approximately 10 ft apart and the diaphragms are at intervals of 25 ft in the tail spans and 21 ft in the cantilevers. The top slab is 10 in. thick and forms the bridge deck; the soffit slab varies in thickness from 14 in. at the pier to 6 in. at the ends. Service mains pass through the diaphragms and below the pre-cast deck beams of the suspended span. Prestressing—the Magnel-Blaton system has been used for the main bridge—was applied through wires embedded in the deck slab and the webs. Construction of the tail spans was on falsework in the normal manner and, on their completion, the cantilevers were built in 10 ft sections using a moving scaffold suspended from the completed section.

The 100 ft suspended span is built up of five I-beams and two edge T-beams at 7 ft 0½ in. centres, pre-cast on the site and partly prestressed after casting. They are supported on a roller bearing at one end and on rockers at the other; 1¼ in. diameter shear connectors have been used at the suspension points. After erection of the longitudinal beams, the diaphragm members were cast and partly prestressed. The deck slab, with a minimum depth of 6 in., was then cast and transversely prestressed with the second (and final) stage of stressing the diaphragms. The longitudinal members were then brought to a state of full prestress.

The main bridge and the south viaduct are integrated in appearance by a pre-cast longitudinal fascia which fits over the top flange of the outside beams. Cast in Snowcrete and

(Above) The new Clifton Bridge over the River Trent, near Nottingham. As part of a future trunk road system, the bridge satisfies the Ministry of Transport standards for abnormal loading. Later, it will be duplicated for a dual carriageway.

(Right) The architectural finish is distinguished by the vertical fluting on the spandrels and the sweeping fascia beam which was cast in Snowcrete and has exposed white aggregate. The ends of the suspended span are marked by spandrel bosses.

Continuing Construction

with an exposed white aggregate it gives the bridge a long sweeping line which contrasts sharply—but pleasingly—with the vertical fluted finish of the spandrel faces. The finish of all the other concrete surfaces is plain.

Because of the tendency of the Trent to periodic flooding, a model study was undertaken at the Hydraulics Research Station at Wallingford, to determine the optimum spacing of piers and the effects of restricting the flow, due to the embankments. The tests established the need for the three-span viaduct on the south side of the river. On the north side the provisional designs called for a multi-span viaduct but the tests showed that a far cheaper embankment, containing a viaduct of three spans, each of 40 ft, would be satisfactory.

Detailed model studies for design purposes were also made by the consulting engineers—R. Morgan Travers and Partners—at the Wexham Spring laboratories of the Cement and Concrete Association. A model, one-fiftieth full size, constructed in Perspex, was tested to check the effects of the skew layout, calculation of the deflections, based on a "square" section, were compared with the data provided by the model. A series of load-deflection and prestress-deflection tests were conducted, together with shear-centre tests, to establish for various positions of the load the transverse positions of the resultant sections at the tailing-down points.

The contractors for the bridge were James Miller and Partners Limited, Spring Vale, Birmingham, 15.

CURRENT STRUCTURAL RESEARCH

The durability of concrete structures, the design of multi-storey steel-frames with rigid joints, stresses in tunnel linings and the stability of earthen flood banks are among the topics which are being currently investigated by the Building Research Station at Garston, Hertfordshire. A brief account of the work now being undertaken at the Station has just been issued and the following is based on that account.

A sufficient number of reinforced-concrete buildings have now been in use for more than 50 years to show that, properly designed, reinforced concrete is as durable material as is likely to be required for most purposes. Adequate cover to the reinforcement, including binding wires and stirrups, is essential, as is the elimination of all unnecessary steelwork. Good concrete, with little or no porosity, must also be used if water is not to penetrate, causing excessive corrosion of the steel, followed by disfigurement of the surface and dangerous spalling. Current research is directed to a study of the effects likely to be incurred by the greater use than hitherto of reinforcement having a higher yield strength. The mechanism of cracking and the characteristics of the bond between concrete and steel are being re-studied to obtain information which will enable designers to ensure that the higher tensile strains developing in concrete (when using high tensile steel) will increase the number of cracks rather than their widths.

The stiffening effects of cladding and floor slabs on the members of frame structures has also been investigated with some success. The results have been incorporated in a series of nomograms and charts which have been reproduced on large separate sheets suitable for desk use; both nomograms and the charts are suitable for either a fully elastic design or a design procedure in which some degree of plasticity is assumed. Savings in steel are promised which are not far short of those ultimately to be expected from "full-collapse" design. Compared with the conventional design method of B.S. 449, savings may be of the order of 15 to 25 per cent. by weight. This gain will to some extent be off-set, however, by the additional work involved in the rigid connections required.

The work on the stresses in tunnel linings has been undertaken in conjunction with the London Transport Executive. It is a subject on which perculiarly little has been known until now, but a greater understanding will be required if underpasses are to become a feature of road improvement schemes in the London area. The investigations have been carried out on lengths of tunnel that were being enlarged. Strain gauges were fixed to some of the existing cast-iron segments and measurements taken before, during, and after the removal of the surrounding clay. From the observed relief of strain, the original stresses in the linings were deduced. For tunnels well separated from each other, the stresses were found to be compatible with the over-burden pressures. Where the tunnels were close together, the results were more complex. Excavation of the second tunnel had obviously caused disturbance in the first, generating tensile strains at some points; in some instances these effects were found to have persisted for 50 years.

The extensive damage caused by the flood tides of February, 1953, to the sea defence banks along the East Coast, and the subsequent failure of some of the remedial measures, have shown that the behaviour of earth banks subjected to flood conditions is also far from being understood. Measurements and visual surveys at the sites of a number of these breaches have now been made, permitting a classification of the failure mechanisms in terms of the dimensions of the banks and construction methods. Gravitational slips of the entire foundation, shallow slips precipitated by excessive pore-water pressure or by water penetration of clay fissures, and erosion of the upper layers of the banks by wave action or over-topping, have been found to be the most common problems. Recommendations for better construction methods have been formulated at the Station.

For more details of the above investigations and to other work undertaken at Garston, inquiries should be addressed to the Director, Building Research Station, Garston, Hertfordshire.

B.P.'S EXPANSION INCLUDES AVIATION SPIRIT

The current expansion at the Isle of Grain refinery of the British Petroleum Company, Limited, is now well under way. When the present stage is complete the refinery will be producing the first B.P. aviation grades distilled in this country. In all, the total output will be increased from about 4·6 million tons per annum to about 7 million tons. When the extensions are finished the whole refinery will have cost approximately £75 million. It was begun in 1950 and, in spite of its size, will only need 2000 personnel.

Among the new items that make up the increased capacity are a crude distillation unit, two Hydrofiner units (for extracting sulphur), reformers and sulphur recovery plant. In addition, more than 100 storage tanks each of about 6 million gallons capacity are being constructed, together with four more jetties. Tankers up to at least 40000 tons can now be handled.

The isopentane column marks the aviation spirit section of the extensions to the Isle of Grain refinery.

Apart from the main fact that the total output of all grades has been increased, the outstanding features are the production of aviation spirit, hitherto a dollar import or else obtained from the refinery at Abadan, now a most uncertain source of supply; and the arrangements that have been made to accommodate changes in the market demands. For a long time the main demand was for petrols and lighter fractions; more recently there has been a shift to gas oils, at first light and now shifting steadily toward the heavier grades as more and more plant is made to burn so-called residual fuels. Quite apart from these major shifts are the seasonal variations—the sales of paraffin may vary as much as two-and-a-half times between summer and winter.

The problem has been met at Grain by an agreement with the South-Eastern Gas Board, who will take not only the waste gases as the North Thames Board are doing at Romford (ENGINEERING, February 14, page 222) but also any grade of oil that happens to be temporarily overproduced at the refinery. To handle this the Gas Board are building a plant adjacent to the refinery which will take the surplus and convert it into town gas. The arrangement offers economic benefits to both parties and probably ultimately to the consumer.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Industrial Closed-Circuit Television," by R. E. Blythe. Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Tues., Mar. 18, 6.30 p.m.*

British Computer Society

LONDON
Address by D. S. Greensmith. Caxton Hall, off Victoria-street, S.W.1. Mon., Mar. 17, 6.15 p.m.

British Institution of Radio Engineers

LONDON
Discussion on "Recommended Method of Expressing Electronic Measuring Instrument Characteristics: A.M. or F.M. Signal Generators." London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Tues., Mar. 18, 6.30 p.m.*
BIRKENHEAD
"Radio Exploration of the Galaxy," by Dr. J. E. Baldwin. Merseyside Section. Birkenhead Technical College, Birkenhead. Fri., Mar. 21, 7 p.m.

Building Centre

LONDON
Films: "Fire Control in Industry," exhibited by Colt Ventilation Ltd. Wed., Mar. 19, 12.45 p.m.

Combustion Engineering Association

SHEFFIELD
Brains Trust on "Space Heating and Insulation," at 11 a.m.* "Boiler Inefficiency:" Part I, "Facts Disclosed by the National Industrial Fuel Efficiency Service (N.I.F.E.S.) Investigations," by L. Clegg; and Part II, "Application of Boiler Research at the British Coal Utilisation Research Association," by D. C. Gunn, at 2.15 p.m. Northern Region. Grand Hotel, Sheffield 1. Wed., Mar. 19.

Diesel Engineers and Users Association

LONDON
"Governing of Diesel Engines," by R. A. Fuller. Caxton Hall, off Victoria-street, S.W.1. Thurs., Mar. 20, 2.30 p.m.

Illuminating Engineering Society

BRISTOL
"Decorative Lighting: A Designer's Approach," by D. W. Durrant. Bath and Bristol Centre. Royal Hotel, Bristol. Mon., Mar. 17, 7 p.m.
LIVERPOOL
"Light as an Effective Aid to Architecture," by R. H. Ruff, R. V. Mills and H. E. Bellchambers. Liverpool Centre. Liverpool Passenger Transport Office, 24 Hatton-garden, Liverpool, 3. Tues., Mar. 18, 6 p.m.
MANCHESTER
"An Architect's Views on Lighting," by J. R. Sheridan. Manchester Centre. Offices of the North Western Electricity Board, Town Hall, Manchester, 2. Thurs., Mar. 20, 6 p.m.*

Incorporated Plant Engineers

LONDON
Discussion on "The Construction of a Nuclear Power Station." London Branch. College of Preceptors, Bloomsbury-square, W.C.1. Thurs., Mar. 20, 7 p.m.*
BIRMINGHAM
Annual General Meeting. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., Mar. 21, 7.30 p.m.
BLACKBURN
Annual General Meeting. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., Mar. 20, 7.30 p.m.
NOTTINGHAM
Annual General Meeting. East Midlands Branch. County Hotel, Theatre-square, Nottingham. Wed., Mar. 19, 7 p.m.
ROCHESTER
"High-Pressure Steam Generation," by O. S. Denham. Kent Branch. King's Head Hotel, High-street, Rochester. Wed., Mar. 19, 7 p.m.

Institute of Fuel

LEEDS
"Conversion of Coal-Fired Plant to Oil Fuel," by T. Marsden. Yorkshire Section. Hotel Metropole, Leeds. Wed., Mar. 19, 2.30 p.m.
LOUGHBOROUGH
"Small Pressurised Water Atomic Power Plants," by H. S. Prossor. East Midland Section. Loughborough College, Loughborough. Thurs., Mar. 20, 7.15 p.m.

Institute of Marine Engineers

LONDON
"Safety at Sea," by Stewart Hogg. Student Lecture. Mon., Mar. 17, 6.30 p.m.*
Annual General Meeting. Discussion on "Should Marine Engineers Have Pre-Seagoing Operational Instruction?" Education Group. Tues., Mar. 18, 5.30 p.m.*
BATH
"Marine Gas Turbine," by B. G. Markham. West of England Section. Smith's Assembly Rooms, Bath. Mon., Mar. 17, 7.30 p.m.
LEEDS
"Nodal Dampers," by G. Hallewell. Kingston upon Hull and East Midlands Section. Hotel Metropole, Leeds. Thurs., Mar. 20, 7.30 p.m.

Institute of Marine Engineers and Institution of Naval Architects

SOUTHAMPTON
Annual General Meeting. "Harland and Wolff Pressure-Charged Two-Stroke Single-Acting Diesel Engine," by C. C. Pounder. Southern Joint Branch. Southampton Technical College, St. Mary-street, Southampton. Wed., Mar. 19, 7.30 p.m.

Institute of Physics

LONDON
Symposium on "Science and Society." William Beveridge Hall, Senate House, University of London, Russell-square, W.C.1. Wed., Mar. 19, 4.30 p.m.*
Annual General Meeting. "Microwave Ferrites," by L. A. Thomas. Electronics Group. Tues., Mar. 18, 5.30 p.m.*
EDINBURGH
"The Liquid State," by Professor J. D. Bernal. Scottish Branch. Department of Natural Philosophy, The University, Edinburgh. Mon., Mar. 17, 7.15 p.m.
GLASGOW
"Structure and Development of the Planets," by Professor J. D. Bernal. Scottish Branch. Department of Natural Philosophy, The University, Glasgow. Tues., Mar. 18, 7.15 p.m.
LEEDS
Annual General Meeting at 5.15 p.m. "Research by Rockets and Satellites," by Dr. R. L. F. Boyd. Yorkshire Branch. Physics Department, The University, Leeds. Wed., Mar. 19, 5.30 p.m.

Institute of Road Transport Engineers

LONDON
Discussion on "Road Transport." Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., Mar. 20, 6.30 p.m.*
EDINBURGH
"Selection and Use of Fuels and Lubricants for Road Transport," by C. T. Tresidder. Scottish Centre. North British Hotel, Edinburgh. Mon., Mar. 17, 7.30 p.m.
LEEDS
"Commer T.S.3 Two-Stroke Diesel Engine," by E. W. Coy. Yorkshire Centre. Great Northern Hotel, Wellington-street, Leeds, 1. Thurs., Mar. 20, 7.30 p.m.

Institution of Chemical Engineers

MANCHESTER
"Heat Transfer in Relation to Nuclear Engineering," by W. B. Hall. North Western Branch. College of Science and Technology, Manchester. Tues., Mar. 18, 7 p.m.

Institution of Civil Engineers

LONDON
James Forrest Lecture on "Further Developments in Nuclear Power," by Sir John Cockcroft. Tues., Mar. 18, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Efficiency and Reciprocity in Pulse-Amplitude Modulation:" Part I "Principles," by K. W. Cattermole; and Part II "Testing and Applications," by J. C. Price; and "Transistor Pulse Generators for Time-Division Multiplex," by K. W. Cattermole. Radio and Telecommunication Section. Wed., Mar. 19, 5.30 p.m.*
"Storage and Manipulation of Information in the Brain," by Dr. R. L. Beurle. Thurs., Mar. 20, 5.30 p.m.*
BRADFORD
"Circuit Breaking and Power System Problems," by C. H. W. Lackey and A. T. Crawford. North Midland Centre. Technical College, Bradford. Tues., Mar. 18, 7 p.m.
BRIGHTON
"British Columbia-Vancouver Island 138 kV Submarine Power Cable," by T. Ingledow and others. Southern Centre. Brighton Technical College, Brighton. Wed., Mar. 19, 6.30 p.m.
CHESTER
"Recent Uses of Ultrasonics in Investigating the Characteristics of Materials," by Dr. J. Lamb. North Western and Mersey and North Wales Centres. Town Hall, Chester. Mon., Mar. 17, 6.30 p.m.
EDINBURGH
"The B.B.C. Sound Broadcasting Service on Very High Frequencies," by E. W. Hayes and H. Page. South East Scotland Sub-Centre. Carlton Hotel, North Bridge, Edinburgh. Tues., Mar. 18, 7 p.m.
GLASGOW
"Potentialities of Railway Electrification at the Standard Frequency," by E. L. E. Wheatcroft and H. H. C. Barton. South West Scotland Sub-Centre. 39 Elmbank-crescent, Glasgow, C.2. Tues., Mar. 18, 7 p.m.

Institution of Heating and Ventilating Engineers

MANCHESTER
Annual General Meeting and Chairman's Address. Manchester Branch. Engineers' Club, Albert-square, Manchester. Fri., Mar. 21, 6.30 p.m.

Institution of Locomotive Engineers

LONDON
Annual General Meeting. "Fuels and Injection Equipment for Traction Diesel Engines," by H. A. Gill and J. M. Smith. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Mar. 19, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion on "How to Bridge the Gap Between Theory and Practice in Lubrication." Lubrication Group. Thurs., Mar. 20, 6 p.m.*
"Failure of a 60 MW Steam Turbo-Generator at Uskmouth Power Station," by A. L. G. Lindley and F. H. S. Brown. Fri., Mar. 21, 6 p.m.*
"Mechanical Engineering Aspects of Investigations on Road Surface Characteristics and Skidding," by K. H. F. Cardew. London Graduates' Section. Tues., Mar. 18, 6.30 p.m.*
BIRMINGHAM
"Economics of Plant Renewal and Replacement," by C. W. Griffiths. Midland Branch. James Watt Memorial Institute, Birmingham. Thurs., Mar. 20, 6 p.m.*
DERBY
"High Compression Ratios for Petrol Engines," by C. L. Goodacre. Derby A.D. Centre. Midland Hotel, Derby. Mon., Mar. 17, 7.15 p.m.
HALIFAX
"Problems of Space Flight," by J. Humphries. Yorkshire Branch. Technical College, Halifax. Thurs., Mar. 20, 7 p.m.
LINCOLN
"Design and Development of a Range of Diesel Engine Turbochargers," by C. L. G. Worn. East Midlands Branch. Technical College, Lincoln. Wed., Mar. 19, 7.15 p.m.
NEWPORT
"Hydro-Kinetic Fluid Drives," by J. G. Giles. South Wales Branch. King's Head Hotel, Newport, Mon. Tues., Mar. 18, 6 p.m.

Institution of Mining and Metallurgy

LONDON
"Betterments in the Quality of Refined Lead," by J. S. Jacobi and B. H. Wadia. Geological Society, Burlington House, Piccadilly, W.1. Thurs., Mar. 20, 5 p.m.

Institution of Production Engineers

LONDON
Annual General Meeting. "Incentive for Indirect Workers," by F. Locke. Royal Empire Society, Northumberland-avenue, W.C.2. Thurs., Mar. 20, 7 p.m.
NORWICH
Annual General Meeting, at 7 p.m. Discussion on "Automation of Copy Turning and Its Development," with film. Norwich Section. Assembly House, Theatre-street, Norwich. Wed., Mar. 19, 8 p.m.
SOUTHAMPTON
"Piston Rings and Liners," by A. Bowler. Southampton Section. Polygon Hotel, Southampton. Thurs., Mar. 20, 7.15 p.m.

Institution of the Rubber Industry

BIRMINGHAM
"Impact of Atomic Energy on Rubber and Plastics," by R. Roberts; and Discussion on "Application of Rubber and Plastics in the Atomic Energy Field." Midland Section. James Watt Memorial Institute, Birmingham. Fri., Mar. 21, 6.45 p.m.

Institution of Structural Engineers

LIVERPOOL
"High-Tensile Steel Bolts," by E. M. Lewis. Lancashire and Cheshire Branch. 9 The Temple, 24 Dale-street, Liverpool. Thurs., Mar. 20, 6.45 p.m.
SWANSEA
"Structures Involving Unusual Design Problems," by C. E. Saunders. Wales and Monmouthshire Branch. Mackworth Hotel, Swansea. Wed., Mar. 19, 6.30 p.m.

Junior Institution of Engineers

LONDON
Film Evening. Fri., Mar. 21, 7 p.m.*

Manchester Association of Engineers

MANCHESTER
"Manchester University Radio Telescope," by H. C. Hushand. Engineers' Club, Albert-square, Manchester. Fri., Mar. 21, 6.45 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE UPON TYNE
"Velocity Measurements in Close Proximity to a Ship's Hull," by R. S. Cutland. Mining Institute, Newcastle upon Tyne. Fri., Mar. 21, 6.15 p.m.*

Royal Aeronautical Society

LONDON
"Problems in the Development of a Guided Missile," by J. Clemow. Royal Institution, Albemarle-street, W.1. Thurs., Mar. 20, 6 p.m.

Royal Meteorological Society

LONDON
Various short papers. Wed., Mar. 19, 5 p.m.*

Royal Society of Arts

LONDON
"Geological Survey of Great Britain—II," by Sir William Pugh. Mon., Mar. 17, 6 p.m.
"Industrial Power of the Future," by Sir Christopher Hinton. Wed., Mar. 19, 2.30 p.m.

Royal Statistical Society

LONDON
"Industrial Production and Steel Consumption," by Sir Robert Shone and H. R. Fisher. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Mar. 19, 5.15 p.m.*

Sheffield Metallurgical Association

SHEFFIELD
"Trends in Basic Refractories," by H. Parnham. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Mar. 18, 7 p.m.

South Wales Institute of Engineers

CARDIFF
"Metallurgy of Haulage and Lifting Gear," by R. Jeffrey and Dr. B. J. Nield. Thurs., Mar. 20, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

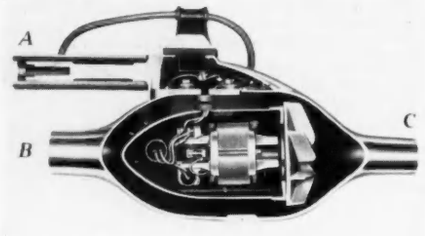
Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Computer Society, 29 Bury-street, St. James's, London, S.W.1.
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. (WHItehall 5536.)
Diesel Engineers and Users Association, 19 Old Queen-street, London, S.W.1. (TRAfalgar 5597.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (BELgravia 6111.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 18 Booth-street, Manchester 2. (Central 1717.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne 1. (Newcastle 20289.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
South Wales Institute of Engineers, Park-place, Cardiff. (Cardiff 23296.)

Engineering at Home

VARIETY BY ATTACHMENT

There is an increasing appreciation of the value of flexibility in domestic equipment. Electric "drills," for example, have developed so many ancillary attachments that they are generally labelled "tools" Other items showing the same mode of development are powered garden tools and vacuum cleaners. The common feature of all is the provision of a single power unit that can be used to drive a variety of accessories. Some new additions to the range are being shown at the Ideal Home Exhibition, Olympia, London.

Landmaster Limited, Hucknall, Nottinghamshire, are exhibiting a multi-purpose machine for digging, hoeing, weeding, mowing, and hedge cutting. It can also be used as a power unit for small tools. The illustration shows the machine, called the Gardenmaster 34, being used to hoe between narrow rows of crops. A 34 c.c. air-cooled two-stroke petrol engine developing 0·75 b.h.p. provides the power.



In the Tornado power unit the universal motor is enclosed in a casing mounted on a rubber block.

The frame carrying the engine has two pressed-steel wheels fitted with rubber tyres. No drive is taken to the wheels but the cutting action of the tool aids forward motion to some extent. The illustration shows cultivating blades attached to the tool head. A shaft carrying the main drive from the engine enters the tool head at about 2500 rev/min, and bevel gears turn the drive through a right angle to the cultivating blades. The reduction ratio to the blades is about 23 : 1.

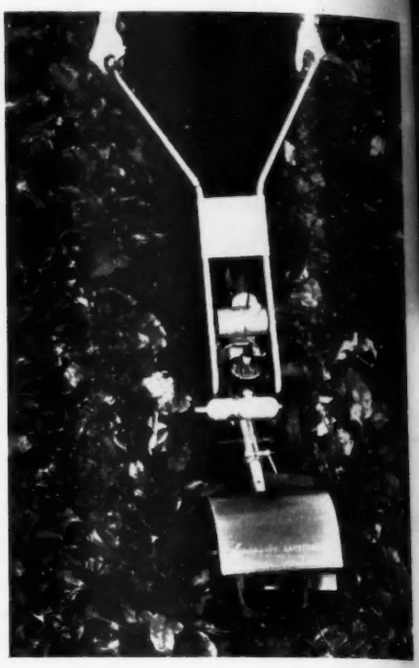
There is no gear change or clutch; control is by throttle only. When used for digging, the rotating blades break up the earth at a speed controlled by the throttle and to a depth determined by the position of the handles. Depths of 6 in. are attainable and by slowly swinging the head from side to side a wide strip can be cultivated. A spin weeder attachment destroys surface weeds and aerates beds and borders.

A rotary mower attachment converts the machine into a lawn mower with a speed of cut controlled by the throttle setting. Hedges can be trimmed by means of a trimmer coupled to 10 ft of flexible drive. The same driving cable can be adapted for use with a number of small power tools, such as grinders, polishers, or drills. The makers claim that the machine operates for about 20 hours on a gallon of fuel.

A pneumatic power unit is shown by Tornado, 26 Macroom Road, London, W.9. The firm offer a large number of attachments that allow such operations as dusting, scraping, polishing floors; dusting pictures, ornaments, and dogs; drying hair, hands, and babies; spraying paint, moth killer and perfume. A cut-away view of the power unit is shown in the left-hand illustration.

The motor unit weighs about 6 lb. It is encased in a container made of Alpax. The 220 watt universal motor, mounted on rubber, is totally enclosed and protected from dust. A turbine speed of 18000 rev/min gives an air current of about 85 cu. ft per minute. As the motor has no filter or belt, no periodic servicing is necessary.

For vacuum cleaning work, a dust bag is fitted on to tube B and a variety of nozzles with or without an extension tube, can be fitted on tube C. A long handle can be fitted on to the Bakelite encased tube A, for floor or ceiling work.



Various attachments can be fitted to the Gardenmaster 34. Here the cultivating blades are loosening the surface and cutting weeds.

For drying applications a tube with an electric heater is fitted to B—the heater supply is obtained from a plug in tube A. For certain applications the air blown out of tube B can be perfumed or treated with disinfectant by the attachment of a filter over tube C that draws the air over the appropriate materials. A spray gun attachment is also available.

CONTROLLED ATMOSPHERE

A basic item influencing the design of an air-conditioning system is the "micro-climate"—the climate existing immediately around the structure to be air conditioned, influenced by structural mass, industry, and other factors which affect the temperature, cleanliness and humidity of the air. The term is used in a paper, "Climatic Influences as a Basic Concept in Air Conditioning," by T. H. Urdahl, who then takes the subdivision further by considering the climate within the structure, as influenced by the structure itself. The paper is published in the *Journal* of the Institution of Heating and Ventilating Engineers (vol. 25, November, 1957).

In his paper the author gives a summary of the development of air conditioning in the United States; but first he discusses the topic of comfort, largely from a point of view expressed by Aldous Huxley. Originally, air conditioning was not introduced for reasons of comfort but was developed for the controlled processing of materials. "It is comfort that introduces complexities into an otherwise strictly engineering problem and makes the work of the air-conditioning engineer a more difficult undertaking," writes Captain Urdahl, who goes on to point out that in designing a system not only do climate and micro-climate have to be taken into account, but individual ideas of comfort must be considered.

Air conditioning in the United States did not get off to a very good start. It became a vogue, which was exploited: many installations were cheap and shoddy. Dehumidification, to use the author's term, was very often omitted and "conditioning" came to mean "cooling." Often the result was clammy, unhealthy discomfort. After the last war, a great many air-conditioning units—especially window models designed for the home—were sold. Many did not meet any established standard. Eventually the public began to realise that cooling was not the only requirement and that humidity control was an important part of an air-conditioning system. The lesson, however, was costly.

The author adopts the definition of the American Society of Heating and Air Conditioning Engineers: air conditioning is "the process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of the conditioned space." In his paper he outlines a method for the graphic representation of the wet-bulb and dry-bulb temperatures over a fixed period, and shows how the graphs may be used as a design tool. Examples are given of cooling-load analyses for different buildings.

A description is given of the air conditioning in the Chamber of Commerce of the United States of America, in Washington D.C. In this building humidity control is accomplished automatically by passing the air required for ventilation, plus a percentage of recirculated air, through desiccant driers automatically re-activated by gas. Air passing through the desiccant (activated alumina) is practically sterile when it leaves. Gas reactivation is not, however, used so often throughout the United States as electrical reactivation.

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